

FDI SPILLOVERS OVER TIME IN AN EMERGING MARKET: THE ROLES OF ENTRY TENURE AND BARRIERS TO IMITATION

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In this study, we examine how foreign direct investment (FDI) spillovers to domestic firms in an emerging market occur *over time*. From the organizational learning perspective, we propose that, as entry tenure of foreign firms in an industry increases, domestic firms can learn from the foreign firms over time and improve their productivity. We further build upon the competitor imitation argument to propose that this effect will be stronger when barriers to imitation faced by the domestic firms are lower. Based upon a comprehensive panel dataset on manufacturing firms in China in 1998–2007, our findings strongly support these arguments. We find that entry tenure of foreign firms in an industry has a positive relationship with the productivity of individual domestic firms in the same industry, albeit at a diminishing rate. We also find that this positive relationship is stronger when the foreign firms have lower export intensity, lower intangible asset intensity, and have followed a more rhythmic (i.e., less irregular) entry pattern—situations characterizing lower barriers to imitation.

Governments, especially those of emerging market countries such as China, have put great emphasis on attracting foreign direct investment (FDI). It has been argued that, in addition to creating employment opportunities and export income, foreign

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firms from developed countries can create positive spillovers to domestic firms in emerging markets, which will be reflected in productivity increases for the latter (e.g., Blomström & Kokko, 1998; Buckley, Clegg, & Wang, 2007; Feinberg & Majumdar, 2001; Spencer, 2008; Zhang, Li, Li, & Zhou, 2010). Most empirical studies on this topic, however, have taken a snapshot approach to examine how the presence of FDI (i.e., the ratio of FDI in an industry) affects domestic firms, and have produced inconsistent findings. While some studies have found positive spillover effects (e.g., Buckley et al., 2007; Tian, 2007), others have demonstrated that foreign firms have no spillover effect or even a negative effect (e.g., Aitken & Harrison, 1999; Feinberg & Majumdar, 2001).

To reconcile the mixed findings, recently, scholars have argued that FDI spillovers do not arise automatically but take place *over time* (De Backer & Sleuwaegen, 2003; Kosová, 2010; Spencer, 2008). Spencer (2008: 347), for example, noted that positive FDI spillovers are likely to occur in the long term because “benefits stemming from access to [foreign firms’] knowledge are likely to take a *sub-*

stantial period of time to accrue" (emphasis added). De Backer and Sleuwaegen (2003) found that new foreign entries decreased domestic firms' entry rate and increased their exit rate; however, the extant presence of foreign firms increased domestic firms' entry rate and decreased their exit rate. Kosova (2010) found that initial foreign entry increased the exit rate of domestic firms, but sales growth of the existing foreign firms increased the growth rate and survival rate of domestic firms. These findings indicate that there may exist crowding-out effects on domestic firms upon foreign entries, but foreign firms may contribute positive benefits to domestic firms in the long run. Thus, it is important for FDI spillover research to shift from the snapshot toward a more dynamic approach.

Note that both De Backer and Sleuwaegen (2003) and Kosova (2010) focused on comparing the effect of new foreign entries with that of existing ones. Their findings thus shed few insights on how the effect of FDI on domestic firms may occur over the course of the FDI presence. Moreover, from a theoretical perspective, how FDI spillovers occur over time may be a more complex process than that which Spencer (2008) has argued. Different from learning in international joint ventures (IJVs), in which partners have incentives to teach each other (e.g., Inkpen & Tsang, 2005), FDI spillovers are unintended movements of knowledge from foreign firms to domestic firms without compensation—or, a "free lunch" (Eden, 2009). Rather than teaching domestic firms, foreign firms often take great efforts to protect their knowledge from being imitated by domestic firms, especially in emerging markets where intellectual property rights are not well protected (Feinberg & Gupta, 2009; Zhang, Li, Hitt, & Cui, 2007; Zhao, 2006). Thus, in the context of FDI spillovers, domestic firms' learning from foreign firms is what Nelson and Winter (1982: 124) would refer to as "imitation from a distance." This point has important implications for our understanding of how FDI spillovers may occur over time. First, since FDI spillovers are domestic firms' "imitation from a distance," there will be a threshold on how much they can learn over time. Second, how much domestic firms can learn from foreign firms over time will depend upon the extent to which foreign firms are imitable "from a distance."

Our study is motivated by the desire to better understand the dynamics of foreign firms' spillovers in an emerging market. We contribute to the literature by explicitly examining the effect of time—more specifically, the "entry tenure" of for-

foreign firms—in FDI spillovers. An individual foreign firm's entry tenure in a host country refers to the time elapsed since the firm was founded in the host country (Zaheer & Mosakowski, 1997). Since multiple foreign firms may exist in an industry and they may have entered at different time periods, for the purpose of our study, we focus on the entry tenure of foreign firms at the industry level, defined as the average of all individual foreign firms' entry tenure in an industry.¹ Drawing upon the FDI spillover literature and the organizational learning perspective (Cyert & March, 1963; Kogut & Zander, 1992; Winter, 2000), we propose that, as the entry tenure of foreign firms in an industry increases, domestic firms can improve their productivity by learning advanced technologies and management practices from the foreign firms over time. However, we do not expect this positive trend to be linear. Instead, domestic firms' productivity will likely increase at a diminishing rate as the foreign firms' entry tenure continues to increase, because obvious learning opportunities will gradually dry up. Our focus on foreign firms' entry tenure allows us to examine how FDI spillovers occur over the course of FDI presence, and, thus, provide direct evidence on the dynamics of FDI spillovers.

Moreover, we draw upon the "competitor imitation" argument to examine how barriers to imitation may affect the effect of time in FDI spillovers. Reed and DeFillippi (1990: 89, emphasis added) argued that, "The ease with which competitive advantage may be sustained or, alternatively, the *speed* with which it is subject to imitation depends upon the height of the barriers [to imitation]." Barriers to imitation can be created by information asymmetry between a firm with competitive advantage and its competitors and/or causal ambiguity of the focal firm's competitive advantage (Lippman & Rumelt, 1982; Reed & DeFillippi, 1990). We propose that some important attributes of foreign firms can affect the height of imitation barriers faced by domestic firms: their market focus (export vs. do-

¹ FDI can take the forms of wholly owned foreign firms and foreign–domestic joint ventures. 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 do not have ownership relationships. To separate the spillover effect from the joint venture effect, we defined "foreign firms" as those with 100% foreign ownership and defined "domestic firms" as those with 100% domestic ownership.

mestic market), asset composition (intangible assets vs. tangible assets), and the rhythm of their entry pattern (a rhythmic vs. an irregular entry pattern). By shaping the height of the barriers to imitation, these attributes of foreign firms can affect the role of time in FDI spillovers: the lower the barriers to imitation, the stronger the positive relationship between foreign firms' entry tenure and domestic firms' productivity in an industry. Based upon a comprehensive panel dataset of Chinese manufacturing firms in 1998–2007, our findings support these arguments. Our findings hold with a number of robustness checks, including using domestic firms' survival as an alternative outcome variable, using various definitions of domestic firms and foreign firms, using various lags for predictors, as well as using random subsamples with various sample sizes.

THEORY AND HYPOTHESIS DEVELOPMENT

FDI Spillovers Over Time

FDI spillovers in an emerging market represent a process in which domestic firms learn from foreign firms (Meyer & Sinani, 2009; Zhang et al., 2010). Such learning occurs because, in an emerging market, foreign firms typically enjoy technological superiority and strong management capabilities that can be transferred to or imitated by domestic firms (Sjöholm, 1999). Domestic firms, due to their technology gaps with foreign firms, also have strong motivation to learn from their foreign counterparts (Hitt, Li, & Worthington, 2005).

Learning, however, takes time to occur. Cyert and March (1963) addressed organizational learning as a process by which organizations as collectives learn through interactions with their environments. In this process, members of the organization search for and share information and knowledge from different sources, creating organizational memory in the form of shared beliefs, assumptions, and norms. These members need time to function as a shared cognition system because "their work as learning agents is unfinished until the results of their inquiry—their discoveries, inventions, and evaluations—are recorded in the media of organizational memory" (Argyris & Schön, 1978: 20). Because alternatives must be first created and an alternative can be effectively assessed only by implementing it, the learning process is likely to be time consuming (Winter, 2000: 984). Thus, organizational learning is a function of time (Simon, 1991).

Built upon this logic, we argue that FDI spillovers, in which domestic firms learn from foreign firms, will occur as the entry tenure of foreign firms in an industry increases. The literature has identified four major spillover mechanisms—demonstration effect, employee turnover, domestic business linkages, and competitive pressure (Blomström & Kokko, 1998; Spencer, 2008)—all of which require a certain amount of time to effect. For demonstration effect, as the entry tenure of foreign firms in an industry increases, domestic firms have a longer time to identify, imitate, and assimilate technologies and management practices used by the foreign firms. They also have more time to try different combinations of these knowledge components, assess the alternative combinations, and utilize the best combination to create their competitive advantage.

Spillovers via employee turnover take time to occur because foreign firms need to hire local employees and train them before they can diffuse the foreign firms' technologies and management practices to their subsequent domestic employers. A 2010 survey of human resources (HR) managers from 1,143 firms in China² found that 27% of foreign firms' HR managers agreed that they faced competitive pressure from domestic non-state-owned firms in talent recruiting and retention, whereas only 17% of HR managers of domestic non-state-owned firms agreed that they faced competitive pressure from foreign firms. Furthermore, according to this survey, domestic non-state-owned firms were attractive to job candidates, especially those at managerial level, because they provided better long-term career advancement prospects and more attractive compensation packages.

Foreign firms' local business linkages, particularly with local suppliers and distributors, are another important spillover mechanism. As foreign firms transfer their technologies and know-how to local suppliers and distributors, such technologies and know-how may be, ultimately, transmitted to domestic firms that use the same suppliers and distributors (Spencer, 2008). However, building local business linkages is time consuming. In the earlier years of their presence, foreign firms often use their parent firms' existing (overseas) suppliers and distributors. As their entry tenure increases,

² The survey was conducted by ManpowerGroup, an international recruitment firm. For further details, see <http://www.manpower.com.cn/surveyreport.html> (note: typo in original URL).

they gradually develop local business linkages (Belderbos, Capannelli, & Fukao, 2001; Spencer, 2008) for cost reasons and/or because of the host country's government's requirement (Osland & Björkman, 1998). In many emerging markets, including China, the host government's "local components" requirement asks foreign firms to use a certain percentage of locally produced components, and this percentage typically increases as foreign firms' entry tenure increases (Osland & Björkman, 1998).

The fourth mechanism, the competitive pressure, works as the increased competition that accompanies foreign entries puts pressure on domestic firms and forces them to update their technologies and adopt advanced management practices to meet this competitive pressure (Blomström & Kokko, 1998). While the effect of competitive pressure does not necessarily require domestic firms' learning from foreign firms, in reality, competitive pressure typically motivates domestic firms to learn from foreign firms. The responding and technology upgrading processes also take time.

Most of the previous studies have investigated foreign firms' spillovers to domestic firms by estimating domestic firms' productivity change (e.g., Aitken & Harrison, 1999; Blomström & Kokko, 1998; Buckley et al., 2007; Feinberg & Majumdar, 2001; Zhang et al., 2010). As Görg and Strobl (2001: 723) noted:

Since MNCs [multinational companies] use a higher level of technology, and technology, or knowledge, has certain characteristics of public goods (Caves, 1996; Markusen, 1995), there is scope for technological externalities and indigenous firms may benefit through spillovers from MNCs. If there are productivity spillovers, the presence of MNCs leads to productivity increases in domestic firms, allowing them to become more efficient.

Following this tradition, we propose:

Hypothesis 1. The entry tenure of foreign firms in an industry has a positive relationship with the productivity of an individual domestic firm in the same industry.

Further, we expect that domestic firms' productivity will improve at a diminishing rate as foreign firms' entry tenure continues to increase. In the early years of foreign firms' presence, technologies and management practices brought by these firms are often very new to domestic firms, thus providing ample opportunities for them to learn and im-

itate. As foreign firms' entry tenure continues to increase, obvious opportunities for domestic firms to learn from the foreign firms—particularly, their codified and discrete knowledge that may be transmitted by careful observation and without extensive interactions (Spencer, 2008)—gradually dry up. Foreign firms' remaining competitive advantage is likely to be created by knowledge that is so idiosyncratic and tacit that "even successful replication becomes problematic, let alone imitation from a distance" (Nelson & Winter, 1982: 124). Therefore, there tends to be a limit on the extent to which domestic firms can improve their productivity by learning from foreign firms over time. Thus:

Hypothesis 2. The positive relationship between the entry tenure of foreign firms in an industry and the productivity of an individual domestic firm in the industry becomes weaker as the foreign firms' entry tenure continues to increase.

Barriers to Imitation and the Role of Time in FDI Spillovers

As noted above, FDI spillovers are different from interorganizational learning in IJVs. In IJVs, mutual interests and trust motivate partners to share knowledge, and contracts and/or organizational routines guide how interorganizational learning occurs (e.g., Inkpen & Tsang, 2005; Steensma, Tihanyi, Lyles, & Dhananraj, 2005). However, in FDI spillovers, foreign firms do not "teach" domestic firms. Instead, they often take great effort to protect their knowledge from imitation by domestic firms (Feinberg & Gupta, 2009; Zhang et al., 2007; Zhao, 2006). Thus, domestic firms' learning from foreign firms in FDI spillovers is what Nelson and Winter (1982: 124) refer to as "imitation from a distance."

Prior studies have argued that the attributes of domestic firms—particularly, their ability to learn and motivation to learn—affect the extent to which they can benefit from FDI spillovers (e.g., Sjöholm, 1999; Zhang et al., 2010). While this line of research provides important insights on FDI spillovers, it only taps one side of the spillover relationship (i.e., domestic firms as the knowledge search firms), but ignores the other side of the relationship (i.e., foreign firms as the knowledge source firms). Since FDI spillovers are the outcome of domestic firms' imitation of foreign firms "from a distance," the extent to which foreign firms are *imitable* "from a distance" should affect how much domestic firms can learn from the foreign firms over time.

Barriers to imitation, or “the restraining or obstructing of imitation by competitors,” can be created by information asymmetry between a firm with competitive advantage and its competitors and/or the causal ambiguity of the focal firm’s competitive advantage (Reed & DeFillippi, 1990: 94). Information asymmetry increases barriers to imitation because, if competitors cannot get sufficient information about a firm with competitive advantage, it would be hard for the competitors to imitate the focal firm (Porter, 1985). Causal ambiguity refers to the “basic ambiguity concerning the nature of the causal connections between actions and results” (Lippman & Rumelt, 1982: 420). It creates barriers to imitation because, even if competitors have full information about a firm, they may not understand how the firm’s competitive advantage arises, making it difficult for them to emulate the focal firm’s strategy (Lippman & Rumelt, 1982; Reed & DeFillippi, 1990).

As Reed and DeFillippi (1990) argued, the *speed* with which a firm’s competitive advantage is subject to its competitors’ imitation depends upon the barriers to imitation. The marginal effect of the entry tenure of foreign firms in an industry on the productivity of individual domestic firms in the industry can be viewed as the *speed* with which the domestic firms learn from the foreign firms to improve their productivity. Following Reed and DeFillippi’s (1990) argument, we propose that the positive relationship between the entry tenure of foreign firms in an industry and domestic firms’ productivity depends upon the barriers to imitation faced by the domestic firms: the lower the barriers, the stronger the positive relationship. In this section, we investigate an array of foreign firms’ attributes—their market focus, asset composition, and rhythm of their entry pattern—that may affect the height of barriers to imitation.

The moderating effect of foreign firms’ market focus. Market focus represents an important strategic choice of foreign firms operating in an emerging market (Luo & Park, 2001; Zhang et al., 2007). Those with an export market focus emphasize exploiting the resource endowments of the host country to meet demands of overseas markets. In contrast, those with a local market focus emphasize reaping benefits from pent-up indigenous demands in the host country (Luo & Park, 2001). We argue that, relative to export focus, foreign firms’ local market focus can lower barriers to imitation faced by domestic firms. First, foreign firms’ local market focus decreases information asymmetry between for-

ign and domestic firms. As foreign firms offer products to meet indigenous demands of the host country market, spillovers via the demonstration effect become more likely to occur as domestic firms are exposed to foreign firms’ product offerings (Zhang et al., 2007). Such foreign firms also have strong incentives to share their knowledge with local distributors and marketing agents in order to penetrate the domestic markets, which increases the likelihood that their technology and know-how will be transmitted to domestic competitors via their local business linkages (Zhang et al., 2007). In contrast, export-focused foreign firms sell few or no products in the host country and have few interactions with local distributors and marketing agents. Since domestic firms do not have much information about these export-oriented foreign firms, it is difficult for them to imitate the foreign firms.

Second, local market-focused foreign firms have more competitive interactions with domestic firms (Meyer & Sinani, 2009) than do export-focused ones. Direct competitive interactions with foreign firms in the host country market motivate domestic firms to proactively search for information about the foreign competitors by closely following and back-engineering their product offerings and accessing their local business linkages. Domestic firms’ proactive information search will further reduce information asymmetry. As Reed and DeFillippi (1990) noted, aggressive competition can lead to faster decay in barriers to imitation. Relatedly, domestic firms in general have a better understanding of the host country market than do foreign firms. To the extent that foreign firms focus on local markets, domestic firms’ local knowledge enables them to better understand foreign firms’ actions and their performance implications (i.e., what will work and what won’t), which can facilitate their learning from the foreign firms. Domestic firms can even combine their local knowledge and new knowledge elements brought by foreign firms to become better than foreign firms in the local markets. Combining these arguments together, we propose that:

Hypothesis 3. The positive relationship between the entry tenure of foreign firms in an industry and the productivity of an individual domestic firm in the industry is stronger when the foreign firms have lower export intensity.

The moderating effect of foreign firms’ asset composition. Firm assets can be generally divided into two broad categories: tangible assets, such as land, plants, equipment, inventories, and other physical assets; and intangible assets, such as pat-

ents, trademarks, copyrights, and trade secrets. Barth, Kasznik, and McNichols (2001) argued that firms with substantial intangible assets have greater information asymmetry between insiders and outsiders. Although the value of intangible assets may be estimated and reported in firms' financial disclosures, their substance is less observable to outsiders. Also, firms typically purchase tangible assets more frequently than intangible assets (Barth et al., 2001; Teece, 1998). Thus, firms' tangible assets are more likely to be observed and imitated by competitors via market transactions. Competitors can even purchase the same or similar tangible assets from the focal firms' suppliers. For these reasons, we argue that foreign firms with higher intangible asset intensity have greater information asymmetry between them and their domestic competitors, which increases the barriers to imitation. Similarly, Tian (2007) argued that tangible assets, such as equipment and production lines, are hard to be protected from domestic firms' imitation whereas intangible assets, such as patents and secret formulae and ingredients, are normally better protected from domestic firms' "stealing." Moreover, Meyer and Sinani (2009: 1077) argued that foreign firms with a higher level of intangible assets are likely to operate in the more upmarket segments in an emerging market, in which "they experience little direct interaction with local firms operating in volume-driven mass markets with small margins." Different market focuses can further increase information asymmetry between foreign and domestic firms.

Intangible assets also have more uncertain payoffs than tangible assets (Barth et al., 2001). This is because payoffs of intangible assets tend to be firm-specific and depend upon what other (tangible and intangible) assets (i.e., complementary assets) the firm has (Teece, 1998). Thus, for foreign firms with higher intangible asset intensity, the causal relationship between their actions and performance is less transparent to domestic firms because of the uncertain payoffs of their intangible assets. Therefore, intangible assets of foreign firms can also create higher barriers of imitation by increasing casual ambiguity of their competitive advantage. For these reasons, we propose that:

Hypothesis 4. The positive relationship between the entry tenure of foreign firms in an industry and the productivity of an individual domestic firm in the industry is stronger when the foreign firms have lower intangible asset intensity.

The moderating effect of foreign firms' entry pattern. The pattern with which foreign firms enter an industry in the host country may also have important implications for barriers to imitation. In their study on firms' internationalization process, Vermeulen and Barkema (2002) investigated how the pattern of a firm's foreign expansion may affect the extent to which the firm can learn from its *own* internationalization experience. They argued that firms following a more rhythmic process can learn better from their experience because they can relate their current foreign expansions to their recent past. In contrast, firms following a more irregular process tend to overstretch their absorptive capacity at peaks of rapid foreign expansions and forget their experience in the long periods of inactivity. Empirically, they found that the positive relationship between the number of a firm's foreign subsidiaries and its performance was stronger if the firm had followed a more rhythmic internationalization process. Different from Vermeulen and Barkema's (2002) work, which focused on the pattern of a firm's *own* foreign expansions (i.e., within-firm pattern) and investigated how this pattern may affect the firm's learning from its *own* experience, we focus on the pattern of foreign firms' entries (i.e., across-firm pattern) at the *industry level* and investigate how this pattern can affect domestic firms' learning from the foreign firms (*other firms*).

Based upon Vermeulen and Barkema (2002), we constructed two figures (Appendix A) that depict two different entry patterns. In a "rhythmic entry pattern," foreign firms enter an industry in a constant and stable pace—for example, a couple of foreign entrants every year. In contrast, in an "irregular pattern," foreign entries are concentrated in a few time periods, followed by long periods with no foreign entries. We argue that, relative to an irregular entry pattern, a rhythmic entry pattern of foreign firms can lower barriers to imitation faced by domestic firms. In an irregular pattern, a large number of foreign firms enter the industry together. It is overwhelming for domestic firms to search for, interpret, and understand technologies and practices brought by the foreign entrants. Their absorptive capability can be overstretched, and they may not be able to devote sufficient time and effort to each of the new entrants. As a result, some important aspects of the foreign entrants may not be noticed or understood, creating greater causal ambiguity regarding the foreign firms' competitive advantage. Moreover, according to the "time compression diseconomies" argument (Dierickx & Cool,

1989), experiences that come too fast will generate fewer benefits than the same experiences would have if they had come in a more gradual, absorbable pattern. So, if foreign firms have followed an irregular entry pattern, domestic firms' learning benefits may be limited due to the time compression diseconomies.³

Conversely, if foreign firms have followed a rhythmic entry pattern, domestic firms only need to pay attention to and observe a few new entrants at a time. The focused attention enables the domestic firms to observe various aspects of the new foreign entrant(s)' operations and thus get a more comprehensive understanding of their competitive advantage. Moreover, domestic firms can gradually develop their knowledge stock by learning steadily from earlier foreign entrants. Thus, they can have stronger absorptive capacity (Cohen & Levinthal, 1990) to draw upon the knowledge elements brought by subsequent foreign entrants. As Brown and Eisenhardt (1997: 24) found in the computer industry, when firms implement and absorb changes in a rhythmical pattern, they may create a flow of attention and "become focused, efficient, and even more confident about the task at hand." For the above reasons, we propose that:

Hypothesis 5. The positive relationship between the entry tenure of foreign firms in an industry and the productivity of an individual domestic firm in the industry is stronger if the foreign firms have followed a more rhythmic (i.e., less irregular) pattern of entering the industry.

³ One may argue that, in an irregular entry pattern, a large number of foreign firms entered an industry in the host country in a short time period; consequently, domestic firms would have little incentive to enter this industry since there are already a large number of players in the market. To rule out this alternative explanation, we conducted additional analyses to investigate how the accumulated number of foreign firms in an industry at the end of the prior year ($Year_{t-1}$) (i.e., the stock of foreign firms) and the number of new foreign entries in the industry in the prior year ($Year_{t-1}$) (i.e., the flow of foreign firms) may affect domestic firms' entries in the industry in a year ($Year_t$). Our results demonstrated that the stock of foreign firms encouraged subsequent domestic entries, while the flow of foreign firms had no significant effect on subsequent domestic entries. Therefore, we are confident that our reported results were not driven by this alternative explanation.

METHODOLOGY

Data Sources and Sample

We tested these hypotheses in the context of China's emerging market, the largest FDI recipient country in the world. The major data source for this study was the Annual Industrial Survey Database (1998–2007) from the Chinese National Bureau of Statistics (CNBS). The database contained the most comprehensive information about domestic and foreign firms in China (Chang & Xu, 2008; Tian, 2007). By law, all firms in China are required to cooperate with and submit their basic and financial information to the CNBS (Chang & Xu, 2008). The database included key firm-level financial information such as sales, capital, and employment, as well as demographic information such as the founding year and ownership details. The aggregation of the firm-level information is published in the official *China Statistical Yearbook*. CNBS statistics have been used by previous studies in the strategy and international business areas (e.g., Chang & Xu, 2008; Tian, 2007; Zhang et al., 2010).

Since 1998, the database covered all state-owned firms, and non-state-owned firms (including foreign ones) with annual sales of RMB 5 million (about US\$670,000 according to the official exchange rate at the end of 2007) or above. Hence, data prior to 1998 were not included in the study to ensure consistency in firm coverage. Also, consistent with previous studies on FDI spillovers (e.g., Javorcik, 2004; Tian, 2007; Zhang et al., 2010), we focused on firms in the manufacturing industries. As noted in Footnote 1, to separate spillover effects from joint venture effects, we defined "foreign firms" as firms with 100% foreign ownership and "domestic firms" as firms with 100% domestic ownership. Our sample consisted of 945,553 domestic firm-year observations, covering 301,667 domestic firms (unevenly distributed across years) in 1998–2007.⁴ These domestic firms covered 511 four-digit Standard Industrial Classification (SIC) code manufacturing industries, accounting for more than 93% of manufacturing industries in

⁴ Data used in this study have some overlap with the data used in Zhang et al. (2010). Zhang et al. (2010) used CNBS data from 1998–2003, whereas this study used CNBS data from 1998–2007. While these two studies unavoidably had overlaps in control variables (e.g., share of foreign firms in an industry), the independent variable and the three moderating variables used in this study were not used in Zhang et al. (2010).

China. Further, data on 223,382 foreign firm–year observations from 64,946 foreign firms were used to calculate FDI-related variables.

Model Specification

Consistent with previous spillover studies (e.g., Aitken & Harrison, 1999; Tian, 2007; Zhang et al., 2010), we estimated how a domestic firm's productivity may be affected by foreign firms. It can be expressed by a log-linear Cobb–Douglas production function as follows.

$$\begin{aligned}
 Y_{ijt} = & \beta_1 \text{Log}K_{ijt} + \beta_2 \text{Log}L_{ijt} + \beta_3 \text{Entry tenure} \\
 & \text{of foreign firms in an industry}_{j(t-1)} \\
 & + \beta_4 \text{Export intensity of foreign firms} \\
 & \text{in the industry}_{j(t-1)} \\
 & + \beta_5 \text{Intangible asset intensity of} \\
 & \text{foreign firms in the industry}_{j(t-1)} \\
 & + \beta_6 \text{Rhythm of entry pattern of} \\
 & \text{foreign firms in the industry}_{j(t-1)} \\
 & + \beta_7 \text{Squared term of entry tenure of} \\
 & \text{foreign firms}_{j(t-1)} \\
 & + \beta_8 \text{Entry tenure of foreign firms}_{j(t-1)} \\
 & \times \text{Export intensity of foreign firms}_{j(t-1)} \\
 & + \beta_9 \text{Entry tenure of foreign firms}_{j(t-1)} \\
 & \times \text{Intangible asset intensity of} \\
 & \text{foreign firms}_{j(t-1)} \\
 & + \beta_{10} \text{Entry tenure of foreign firms}_{j(t-1)} \\
 & \times \text{Rhythm of entry pattern of} \\
 & \text{foreign firms}_{j(t-1)} \\
 & + \beta_{11} \text{Controls} + \alpha_{ij} + \epsilon_{ijt} \quad (1)
 \end{aligned}$$

Log output Y_{ijt} for domestic firm i in industry sector j (defined at the four-digit SIC code level) at time t was regressed on its inputs (Log K_{ijt} and Log L_{ijt}) and the entry tenure of foreign firms in the industry sector j at time $t - 1$ and the foreign firms' export intensity, intangible asset intensity, and rhythm of their entry pattern in sector j at time $t - 1$, as well as their interaction terms. We used firm annual sales for firm output (Chung, Mitchell, & Yeung, 2003). To remove the effects of deflation or inflation due to price change over time, we deflated firm sales using the year 2000's constant price (Aitken & Harrison, 1999; Tian, 2007). Firm inputs included 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 GDP deflator on the basis of the year 2000's constant price (Aitken & Harrison, 1999; Tian, 2007). A vector of controls (measured at year $t - 1$) was also included. Further, α_{ij} was an unobserved effect for domestic firm i in sector j , and ϵ_{ijt} was the error term. This model specification used one-year lag for predictors and controls.

Measurement

Measurement of predictors. In this study, we first calculated the entry tenure of each foreign firm⁵ in the industry, referring to the number of years since the firm was founded in China. We then calculated the mean of individual foreign firms' entry tenure, weighted by their asset sizes, to measure *entry tenure of foreign firms* at the industry level. We used the weighted measure to take into account the fact that large foreign firms tend to have greater impact on domestic firms than do small ones.

There are alternative ways to operationalize entry tenure of foreign firms at the industry level, such as tenure of the earliest entrant and tenure of the largest entrant. However, we believe that our measure is better than the other options. It is common that small foreign investments were tried in an emerging market before larger commitments were made (by the same foreign investors or by other foreign investors). The measure of "tenure of the earliest entrant" would ignore the effects of later (probably larger and more important) foreign entrants. On the other hand, the measure of "tenure of the largest entrant" would ignore foreign entrants that entered the host country before the largest entrant. Compared to these two alternatives, our measure took into account the effects of all foreign entrants and their sizes.

In our data, the entry tenure of individual foreign firms ranged between 1 and 30 years; the (mean of) entry tenure of foreign firms at the industry level ranged between 1 and 24 years. The wide ranges of these variables allowed us to test our hypotheses. We also used alternative foreign firm size measures (i.e., employment and sales size) as the weight, as

⁵ If a foreign investor had registered multiple subsidiaries in China, each subsidiary was treated as a separate foreign firm. That is, our definition of foreign firms was at the subsidiary level instead of at the corporate level.

well as simple average entry tenure of foreign firms, and got highly consistent results.

Export intensity of foreign firms in an industry was measured as the sum of foreign firms' export sales divided by the sum of their total sales. *Intangible asset intensity of foreign firms* in an industry was measured as the sum of foreign firms' intangible assets divided by the sum of their total assets. In the CNBS survey database, tangible assets included land, plants, equipment, inventories, and other physical assets; intangible assets included patents, non-patented technologies, trademarks, copyrights, trade secrets, and other nonphysical assets (Tian, 2007).

We followed Vermeulen and Barkema's (2002: 644) measure of the rhythm of a firm's internationalization process to create the measure of rhythm of foreign firms' entry pattern in an industry. In Appendix A, the upper graphs depict the total number of foreign firms in an industry by year and the bottom graphs depict the change in the number of foreign firms in an industry by year. *Rhythm of foreign firms' entry pattern* was measured by the kurtosis of this distribution:

$$\text{kurtosis} = \left\{ \frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum \left(\frac{x_i - \bar{x}}{s} \right)^4 \right\} - \frac{3(n-1)^2}{(n-2)(n-3)} \quad (2)$$

where n = number of foreign firms in the industry, x_i = entry tenure of foreign firm i , and s = standard deviation of the entry tenure of foreign firms in the industry. Values of the kurtosis in our data ranged between -6 and 11 , with higher values indicating more irregular entry patterns and lower values indicating more rhythmic entry patterns. For ease of interpretation, we recoded it by multiplying (-1) so that higher values indicate more rhythmic entry patterns. All of these predictors were calculated for each four-digit SIC code industry in the sample and updated yearly.

Measurement of controls. Most previous studies on FDI spillovers have focused on the effect of FDI share in an industry (e.g., Aitken & Harrison, 1999; Javorcik, 2004; Tian, 2007). We controlled for *share of foreign firms* in an industry, measured by the ratio of the foreign firms' sales to the industry's total sales. Or, we measured it as the ratio of the foreign firms' employment (or assets) to the industry's total employment (or assets). These alternative measures produced virtually the same results. In many industries in China, there have been a mix of

wholly owned foreign firms and IJVs. To rule out the possible effect of IJVs on domestic firms that were not the domestic partners of the IJVs, we controlled for the (logged) *number of IJVs* in the industry in the prior year, referring to firms where foreign ownership was equal to or larger than 50% but less than 100%. Since foreign partners are more likely to contribute their technologies and skills to IJVs if they have majority ownership (e.g., Yan & Gray, 1994), IJVs in which foreign partners own 50% or more should be more relevant from a spill-over perspective. Alternatively, we used 25% foreign ownership as a cut-off (minimum foreign ownership for being legally considered as a foreign firm in China) and got virtually the same results.

We also controlled for the following important attributes of individual domestic firms that may affect their productivity and/or their motivation/ability to learn from foreign firms. A *domestic firm's age* was measured by the number of years since it was founded. Its squared term was also controlled for. *State ownership* of a domestic firm was coded "1" if a domestic firm was state owned and "0" otherwise. Since some domestic firms' state ownership changed in our research time period, this variable was updated yearly. A *domestic firm's export intensity* may affect its productivity and its motivation/ability to learn from foreign firms. It was measured as the ratio of a domestic firm's export sales to its total sales. A *domestic firm's intangible asset intensity* was also controlled for and was measured as the ratio of the firm's intangible assets to its total assets. A domestic firm's spatial relationships with foreign firms may also matter. We controlled for a *domestic firm's collocation density of foreign firms*, measured by the (logged) number of foreign firms in the industry that were located in the domestic firm's province. All domestic firm-related variables were updated yearly. Moreover, to capture the possible effect of China's economic change over time, we included *calendar year dummies*. We also controlled for *region dummies* at the provincial level and *industry dummies* at the two-digit SIC code level.

Correction for Survival Bias

Our sample was an unbalanced panel of domestic firms with varying survival lengths. Firms with higher productivity in one year are more likely to survive in the next year. Therefore, our estimation of individual domestic firms' productivity was subject to their survival bias. To correct for this possi-

ble bias, we estimated the likelihood that a domestic firm will survive in year $t + 1$, using predictors including the domestic firm's age and its squared term, its total profit, the average labor productivity of firms in the industry, and the number of foreign firms in the industry and its squared term (all measured in year t). The domestic firm's size was not included because it was highly correlated with its total profit. Following Chatterjee and Hambrick (2007), we used the "xtprobit" command in the statistical software package Stata for this estimation and calculated the inverse Mill's ratio from the estimation (Data in year 2008 was added to calculate the inverse Mill's ratio for firm observations in the year 2007). The inverse Mill's ratio was then included as a control in our models estimating individual domestic firms' production function.

Data Analyses

Based upon Wooldridge (2002), we adopted the following procedures for data analyses. First, we used the Breusch-Pagan Lagrange multiplier test to decide whether the panel data method or the pooled ordinary least squares approach was more appropriate. The results of the test suggested that unobserved individual effects existed in the data. Thus, the panel data method was used because this method can model the unobserved individual effects associated with the same units. Second, for the panel data method, we needed to choose between fixed effect and random effect models. The results of Hausman test revealed that explanatory variables were correlated with the unobserved effects, and, thus, fixed effect models should be used. We therefore followed Wooldridge (2002: 267) and conducted a fixed effect transformation (also called the "within transformation") to eliminate unobservable firm effects. We added year dummies, industry dummies, and region dummies after the firm-fixed effect transformation in order to control for time-varying unobservable region and industry effects (the firm-fixed effect transformation only eliminates the unobserved effects that do not change over time), which may drive changes in attractiveness of a particular region or industry (Javorcik, 2004: 616). Finally, we used the modified Wald test to check for heteroscedasticity, and the results suggested that this was an issue. We therefore clustered standard errors at the firm level to adjust for heteroscedasticity.

RESULTS

Table 1 reports the descriptive statistics and correlations of the variables used in this study, except for year dummies, region dummies, and industry dummies (for space reasons). Table 2 presents firm-fixed effect models of individual domestic firms' production function. Model 1 features the controls only, Model 2 adds the predictors' main effects, and Model 3 adds the interaction terms. Alternatively, we added the interaction terms one by one and the results were virtually the same as those for Model 3. Variables were mean-centered prior to creating the interaction terms in order to reduce concerns of multicollinearity (Aiken & West, 1991).

The coefficient of the entry tenure of foreign firms is positive and significant ($b = 0.016$, $p < 0.001$, Model 3 in Table 2), meaning that it has a significantly positive relationship with a domestic firm's productivity. Hypothesis 1 is thus supported. The coefficient for its squared term is negative and significant ($b = -0.002$, $p < 0.001$, Model 3 in Table 2). To facilitate interpretation, we plotted this curvilinear effect in Figure 1, following the procedure recommended by Aiken and West (1991). As shown in Figure 1, the entry tenure of foreign firms in an industry has an overall positive relationship with a domestic firm's productivity, although the slope of this positive relationship diminishes (but doesn't turn negative) as the entry tenure of the foreign firms continues to increase. Hypothesis 2 is thus supported. To demonstrate practical implications of these results, we calculated the effect size following the approach used by Aitken and Harrison (1999: 609). All else being equal, as the entry tenure of foreign firms in an industry increased from 1 year to 10 years, a domestic firm's output would increase by 14.4%.⁶ Since we have controlled for differences in the domestic firm's capital and labor input, the 14.4% increment is a pure total factor productivity gain, indicating significant practical importance.

⁶ As the entry tenure of foreign firms in an industry increased from 1 year to 10 years, this variable had the following vector of values: [1, 2, . . . , 9, 10]. The group mean of this vector is 5.5. After fixed effect transformation (minus the group mean of 5.5), the vector was transformed to [-4.5, -3.5, . . . , 3.5, 4.5]. All else being equal, the difference in domestic firms' productivity as the entry tenure of foreign firms in an industry increased from 1 year to 10 years would be: $\{[0.016 \times 4.5 + (-0.002) \times (4.5)^2] - [0.016 \times (-4.5) + (-0.002) \times (-4.5)^2]\} = 0.144$.

TABLE 1
Means, Standard Deviations, and Correlations of Variables^{a,b,c,d}

Variables	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Log <i>Y</i>	9.740	1.387	1.000												
2. Log <i>K</i>	9.522	1.393	0.659	1.000											
3. Log <i>L</i>	4.738	1.095	0.574	0.688	1.000										
4. Entry tenure of foreign firms in an industry	6.590	1.861	0.063	-0.085	-0.105	1.000									
5. Export intensity of foreign firms	0.389	0.257	-0.064	-0.150	0.016	0.122	1.000								
6. Intangible asset intensity of foreign firms	0.034	0.055	-0.063	0.027	0.023	-0.194	-0.159	1.000							
7. Rhythm of entry pattern of foreign firms	-0.118	1.543	0.056	-0.012	-0.023	0.129	0.076	-0.023	1.000						
8. Share of foreign firms	0.140	0.130	-0.027	-0.121	-0.058	0.269	0.507	-0.172	0.134	1.000					
9. Number of IJVs	3.293	1.265	0.045	-0.042	0.006	0.207	0.154	-0.140	0.008	0.264	1.000				
10. Domestic firm's age	11.103	12.79	-0.067	0.215	0.268	-0.131	-0.056	0.096	-0.085	-0.124	-0.114	1.000			
11. Domestic firm's state ownership	0.163	0.370	-0.214	0.157	0.137	-0.190	-0.145	0.154	-0.110	-0.170	-0.136	0.457	1.000		
12. Domestic firm's export intensity	0.105	0.285	0.042	-0.036	0.115	0.082	0.311	-0.057	0.051	0.215	0.119	-0.042	-0.100	1.000	
13. Domestic firm's intangible assets intensity	0.020	0.060	0.040	0.137	0.073	0.021	-0.030	0.015	0.019	0.002	-0.003	0.030	-0.010	0.015	1.000
14. Domestic firm's colocation density of foreign firms	1.551	1.557	0.088	-0.106	-0.064	0.236	0.311	-0.133	0.130	0.432	0.561	-0.201	-0.268	0.243	-0.020

^a $n = 945,553$ firm-year observations.

^b Year dummies, region dummies, and industry dummies are not included in this table for space reasons, but were included in all models.

^c Correlations with absolute values equal to or greater than 0.002 are significant at the level of $p < 0.05$.

^d Correlation coefficients between some control variables are greater than 0.4, which may raise concerns of multicollinearity. In supplementary analyses, we dropped these control variables in models and obtained highly consistent results.

TABLE 2
Firm-Fixed Effect Models of Domestic Firm Production Function^{a,b,c}

Variables	Model 1		Model 2		Model 3	
Log <i>K</i>	0.382***	(0.002)	0.379***	(0.002)	0.379***	(0.002)
Log <i>L</i>	0.376***	(0.003)	0.380***	(0.003)	0.380***	(0.003)
Predictors						
Entry tenure of foreign firms in an industry			0.016***	(4.73E-04)	0.016***	(4.74E-04)
Export intensity of foreign firms			-0.049***	(0.005)	-0.051***	(0.005)
Intangible asset intensity of foreign firms			-0.054***	(0.011)	-0.029*	(0.011)
Rhythm of entry pattern of foreign firms			0.005***	(4.13E-04)	0.005***	(4.13E-04)
Interactions						
Squared term of entry tenure of foreign firms in an industry					-0.002***	(1.16E-04)
Entry tenure of foreign firms in an industry × Export intensity of foreign firms					-0.006***	(1.51E-03)
Entry tenure of foreign firms in an industry × Intangible asset intensity of foreign firms					-0.032***	(0.004)
Entry tenure of foreign firms in an industry × Rhythm of entry pattern of foreign firms					6.95E-04***	(2.17E-04)
Controls						
Share of foreign firms	0.045***	(0.011)	0.010	(0.011)	0.006	(0.011)
Number of IJVs	3.63E-03**	(1.24E-03)	1.78E-03	(1.25E-03)	-2.12E-04	(1.26E-03)
Domestic firm's age	0.002***	(1.24E-04)	0.002***	(1.24E-04)	0.002***	(1.24E-04)
Domestic firm's age squared	-5.88E-05***	(4.32E-06)	-5.13E-05***	(4.27E-06)	-5.11E-05***	(4.25E-06)
Domestic firm's state ownership	0.002	(0.002)	8.94E-04	(0.002)	0.001	(0.002)
Domestic firm's export intensity	0.029***	(0.004)	0.029***	(0.004)	0.029***	(0.004)
Domestic firm's intangible asset intensity	-0.092***	(0.013)	-0.101***	(0.013)	-0.101***	(0.013)
Domestic firm's colocation density of foreign firms	0.026***	(0.001)	0.022***	(0.001)	0.021***	(0.001)
Inverse Mill's ratio	-1.359***	(0.013)	-1.287***	(0.013)	-1.306***	(0.013)
Region dummies	Included		Included		Included	
Industry dummies	Included		Included		Included	
Year dummies	Included		Included		Included	
<i>F</i> value	2,139***		2,069***		1,983***	
Within <i>R</i> ²	0.2636		0.2651		0.2655	
Total <i>R</i> ²	0.9306		0.9308		0.9309	
<i>F</i> value for <i>R</i> ² change	—		M2 vs. M1 241.37***		M3 vs. M2 74.07***	

^a *n* = 945,553 firm-year observations.

^b Estimated coefficients and associated robust standard errors (in parentheses) are reported.

^c The models do not have constants because the fixed effect transformation has removed the intercept term.

* *p* < .05 (two-tailed tests)

** *p* < .01

*** *p* < .001

In Model 3 in Table 2, the interaction term of the entry tenure of foreign firms and the foreign firms' export intensity is negative and significant (*b* = -0.006, *p* < 0.001, Model 3 in Table 2). We plotted this interaction effect, following the procedure recommended by Aiken and West (1991), in Figure 2. The plot depicts that the positive relationship between the entry tenure of foreign firms in an industry and the productivity of a domestic firm in the industry is stronger when the foreign firms' export

intensity is low (one standard deviation below mean) than when it is high (one standard deviation above mean). Thus, Hypothesis 3 is supported. The interaction term of the entry tenure of foreign firms and the foreign firms' intangible asset intensity is negative and significant (*b* = -0.032, *p* < 0.001, Model 3 in Table 2). The plot of this interaction effect in Figure 3 demonstrates that the positive relationship between the entry tenure of foreign firms in an industry and the productivity of a do-

FIGURE 1

Entry Tenure of Foreign Firms in an Industry and Domestic Firm Productivity: A Nonlinear Effect

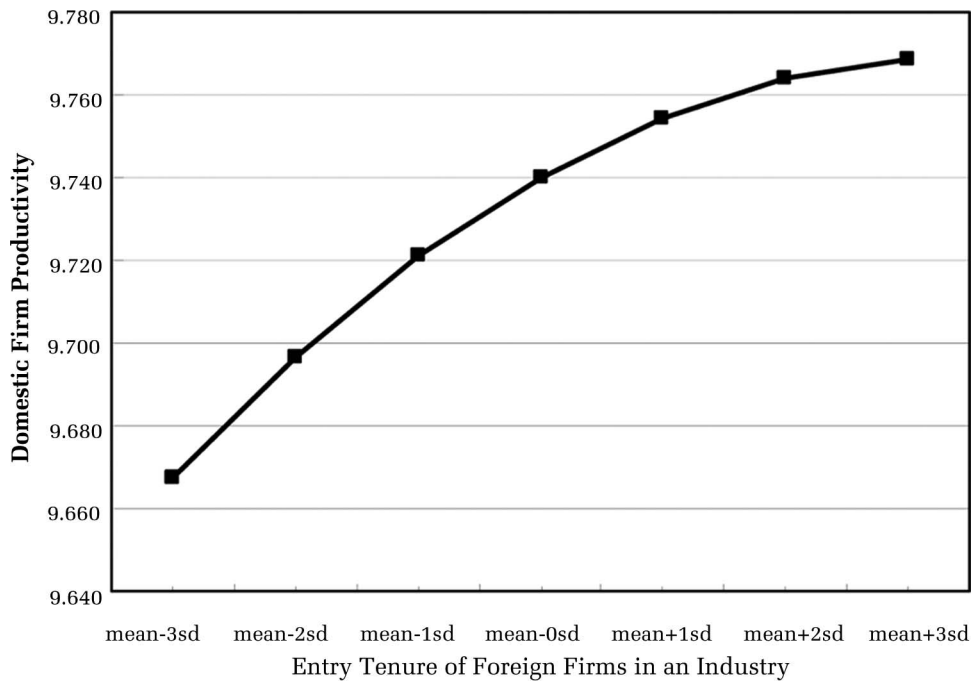


FIGURE 2

Entry Tenure of Foreign Firms in an Industry and Domestic Firm Productivity: The Moderating Role of the Export Intensity of Foreign Firms

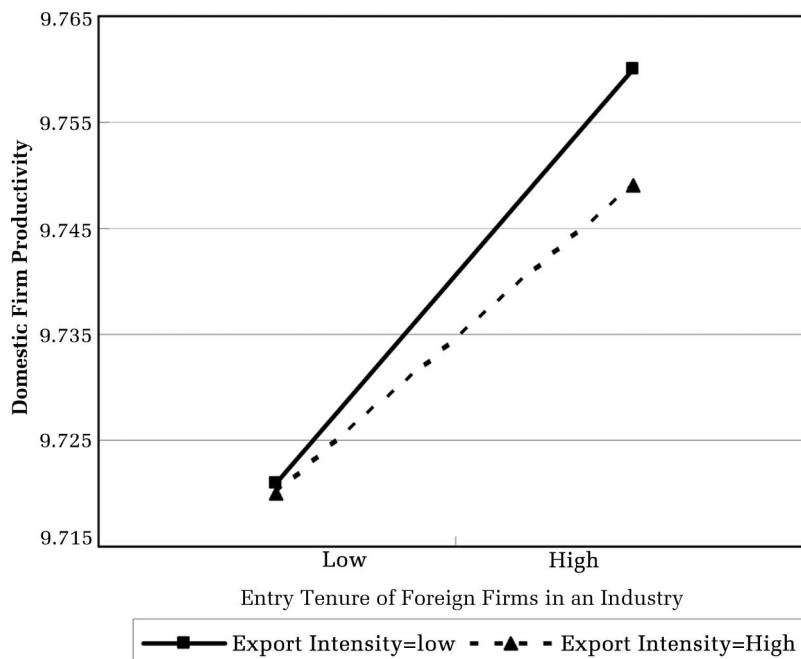
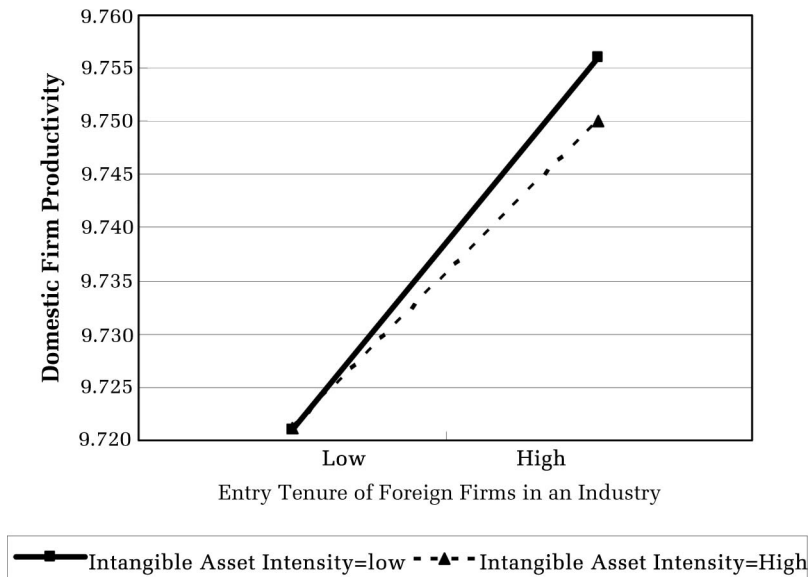


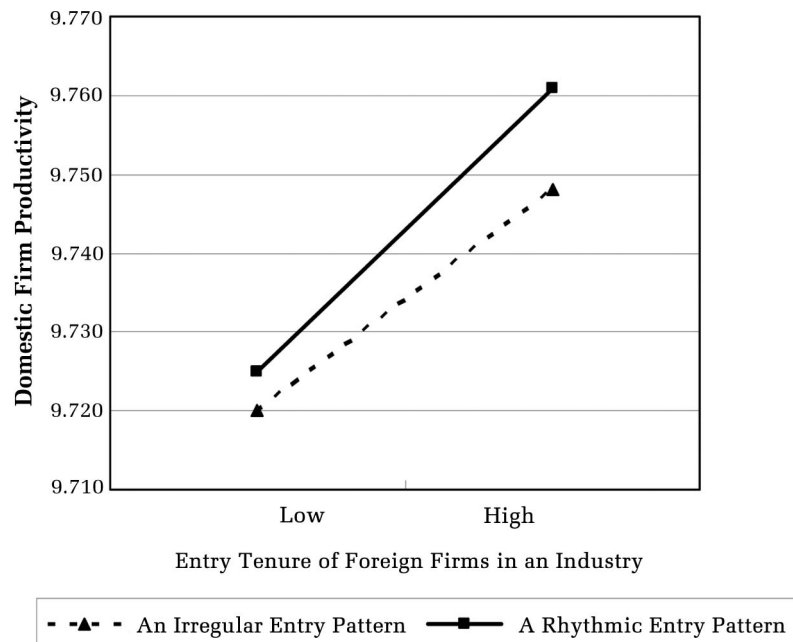
FIGURE 3
Entry Tenure of Foreign Firms in an Industry and Domestic Firm Productivity: The Moderating Role of the Intangible Assets Intensity of Foreign Firms



mestic firm in the industry is stronger when the foreign firms' intangible asset intensity is low than when it is high. Thus, Hypothesis 4 is also supported. The interaction term of the entry tenure of

foreign firms and the rhythm of their entry pattern is positive and significant ($b = 6.95E-04, p < 0.001$). The plot of this interaction effect in Figure 4 depicts that the positive relationship between the

FIGURE 4
Entry Tenure of Foreign Firms in an Industry and Domestic Firm Productivity: The Moderating Role of the Rhythm of Entry Pattern of Foreign Firms



entry tenure of foreign firms in an industry and the productivity of a domestic firm in the industry is stronger if the foreign firms have followed a rhythmic entry pattern than if they have followed an irregular entry pattern. These results support Hypothesis 5.

Supplementary Analysis I: Domestic Firms' Survival as an Alternative Outcome Variable

In addition to domestic firms' productivity, another important outcome variable in the FDI spillover literature is the survival/exit of domestic firms (e.g., Chang & Xu, 2008; De Backer & Sleuwaegen, 2003; Kosová, 2010). We used this alternative outcome variable to check the robustness of our findings. Exit of a domestic firm in a year was coded "1" if the domestic firm was included in the CNBS Annual Industrial Survey Database in the prior year but not in the current year, and "0" otherwise. We estimated the likelihood of a domestic firm's exit using the Gompertz model, following previous studies on organizational mortality (e.g., Carroll & Delacroix, 1982; Freeman, Carroll, & Hannan, 1983). A negative coefficient would mean that a

predictor has a negative (positive) relationship with the likelihood of domestic firms' exit (survival). Results are reported in Table 3. The entry tenure of foreign firms in an industry ($b = -0.012$, $p < 0.001$, Model 3 in Table 3) has a negative (positive) relationship with the likelihood of domestic firms' exit (survival). The coefficient for its squared term ($b = 0.005$, $p < 0.001$) is positive and significant, suggesting that the negative (positive) relationship between the entry tenure of foreign firms in an industry and the likelihood of exit (survival) of a domestic firm in the industry becomes weaker as the entry tenure of the foreign firms continues to increase. These results are consistent with the predictions of Hypotheses 1 and 2, had a domestic firm's survival been used as the dependent variable.

The interaction of the entry tenure of foreign firms in an industry with the foreign firms' export intensity ($b = 0.048$, $p < 0.001$) and its interaction with the foreign firms' intangible asset intensity ($b = 0.105$, $p < 0.01$) are both positive and significant. These results indicate that the negative (positive) relationship between the entry tenure of for-

TABLE 3
Models of Domestic Firm Exit^{a,b,c}

Variables	Model 1	Model 2	Model 3
Predictors			
Entry tenure of foreign firms in an industry		-0.013*** (0.002)	-0.012*** (0.002)
Export intensity of foreign firms		0.076*** (0.016)	0.091*** (0.017)
Intangible asset intensity of foreign firms		-0.630*** (0.076)	-0.801*** (0.080)
Rhythm of entry pattern of foreign firms		-0.006*** (1.75E-03)	-0.005** (1.75E-03)
Interactions			
Squared term of entry tenure of foreign firms in an industry			0.005*** (4.94E-04)
Entry tenure of foreign firms in an industry × Export intensity of foreign firms			0.048*** (0.006)
Entry tenure of foreign firms in an industry × Intangible asset intensity of foreign firms			0.105** (0.036)
Entry tenure of foreign firms in an industry × Rhythm of entry pattern of foreign firms			0.001 (0.001)
Controls			
(All controls listed in Table 2 except inverse Mill's ratio and Log K^c were included.)			
Pseudo-log-likelihood	-221,804	-221,747	-221,670
Wald chi-square	5.54E+07***	5.54E+07***	5.49E+07***

^a Number of firm-year observations = 945,553; number of exits = 113,633.

^b Estimated coefficients and associated robust standard errors (in parentheses) are reported.

^c Only one measure of firm size (Log L or Log K) was needed for inclusion in the model. We included Log L , but including Log K produced virtually the same results.

* $p < .05$ (two-tailed tests)

** $p < .01$

*** $p < .001$

foreign firms in an industry and the likelihood of exit (survival) of a domestic firm in the industry is stronger when the foreign firms' export intensity is lower, and/or when their intangible asset intensity is lower. These findings are consistent with the predictions of Hypotheses 3 and 4. However, the interaction of the entry tenure of foreign firms in an industry and the rhythm of their entry pattern is not significant. Overall, our results on domestic firm survival are generally consistent with those on domestic firm productivity, with the exception of Hypothesis 5.

Supplementary Analysis II: Addressing the Issue of Left-Censoring

In Table 2, we used foreign firms present in 1998–2007 to calculate FDI-related variables. Foreign firms that entered China before 1998, as long as they were present in 1998 or after, were included in the calculation. However, it is possible that some foreign firms entered China before 1998 and exited before 1998. These foreign firms may have created spillovers or competition effects on domestic firms prior to their exit. In this sense, our data may be

left-censored. To address this issue, we re-estimated the models in Table 2 by focusing only on domestic firms that were founded in 1998 or after. These domestic firms did not coexist with foreign firms that exited prior to 1998, and thus were not affected by those foreign firms. Using this subgroup of domestic firms thus enabled us to address the issue of left-censoring. The results are reported in Table 4, and they are highly consistent with those reported in Table 2. Thus, we are confident that our results were not driven by the left-censoring issue.

Supplementary Analysis III: Effects of Foreign Firms in Different Geographic Locations

In Table 2, we used all foreign firms in an industry, in a year, to calculate FDI-related variables. This approach assumed that all foreign firms in the industry were relevant, albeit their relevance was weighted by their sizes, to the focal domestic firms. However, geographic proximity may make differences: foreign firms located in the same region as the focal domestic firms may matter more to the focal domestic firms than those outside the region. To address this issue, we ran two supplementary

TABLE 4
Firm-Fixed Effect Models of Production Function of Domestic Firms Founded in 1998 or Later^{a,b}

Variables	Model 1	Model 2	Model 3
Log <i>K</i>	0.340*** (0.003)	0.338*** (0.003)	0.338*** (0.003)
Log <i>L</i>	0.333*** (0.003)	0.333*** (0.003)	0.333*** (0.003)
Predictors			
Entry tenure of foreign firms in an industry		0.008*** (7.42E-04)	0.008*** (7.41E-04)
Export intensity of foreign firms		-0.064*** (0.008)	-0.065*** (0.008)
Intangible asset intensity of foreign firms		-0.321*** (0.036)	-0.339*** (0.037)
Rhythm of entry pattern of foreign firms		0.004*** (7.27E-04)	0.003*** (7.29E-04)
Interactions			
Squared term of entry tenure of foreign firms in an industry			-9.56E-04*** (1.76E-04)
Entry tenure of foreign firms in an industry × Export intensity of foreign firms			-0.011*** (0.002)
Entry tenure of foreign firms in an industry × Intangible asset intensity of foreign firms			-0.042** (0.015)
Entry tenure of foreign firms in an industry × Rhythm of entry pattern of foreign firms			0.003*** (3.74E-04)
Controls			
(All controls listed in Table 2 were included.)			
<i>F</i> value	1,119***	1,070***	1,022***
Within <i>R</i> ²	0.2773	0.2780	0.2783
Total <i>R</i> ²	0.9290	0.9291	0.9292

^a *n* = 438,729 firm-year observations.

^b Estimated coefficients and associated robust standard errors (in parentheses) are reported.

* *p* < 0.05 (two-tailed tests)

** *p* < 0.01

*** *p* < 0.001

analyses. In Model A of Table 5, FDI-related variables were calculated using data on foreign firms in the same province as the focal domestic firms only (i.e., within-region foreign firms). In Model B of Table 5, FDI-related variables were calculated using data on foreign firms outside the province of the focal domestic firms (i.e., outside-region foreign firms). Our hypotheses are generally supported by the results of both analyses, except that the moderating effects of foreign firms' intangible asset intensity (Hypothesis 4) and the rhythm of their entry pattern (Hypothesis 5) are not supported in Model A (within-region foreign firms).

Supplementary Analysis IV: Effects of Foreign Firms With Different Country Origins

Foreign firms' country origins may also matter. Buckley et al. (2007) and Chang and Xu (2008) divided foreign firms in China into two groups: those from Hong Kong, Macau, and Taiwan (hereafter, "HMT") and those from other countries. Due to these regions' historical and social linkages with mainland China, foreign firms from HMT have some access to local knowledge and local resources and thus have greater resource similarity with domestic firms than with foreign firms from other countries (Chang & Xu, 2008). To check for any potentially different effects of these two groups of foreign firms, in Model C of Table 5, FDI-related variables were calculated using data on foreign firms from HMT only, while, in Model D, FDI-related variables were calculated using data on foreign firms from other countries. Results of these two analyses consistently support the predictions of Hypotheses 1–4, but not that of Hypothesis 5.

Supplementary Analysis V: Alternative Definitions of "Foreign Firms" and "Domestic Firms"

In earlier analyses, "foreign firms" referred to firms with 100% foreign ownership and "domestic firms" referred to firms with 100% domestic ownership. We used alternative cut-offs to define domestic firms and foreign firms. Table 6 summarizes the results. In Models A–C, domestic firms referred to those with domestic ownership greater than 95% (Model A), 80% (Model B), and 75% (Model C), respectively (foreign firms referred to those with 100% foreign ownership). In Models D–F, foreign firms referred to those with foreign ownership greater than 95% (Model D), 80% (Model E), and

75% (Model F), respectively (domestic firms referred to those with 100% domestic ownership). Results of these models are highly consistent with one another as well as with those reported in Table 2. Thus, our results are robust to alternative definitions of "domestic firms" and "foreign firms."

Supplementary Analysis VI: Using Longer Lags

In the analyses reported in Table 2, we used a 1-year lag for predictors. For robustness checks, we used longer lags. The results are reported in Table 7, in which Models A–D used 2-, 3-, 4-, and 5-year lags, respectively. The entry tenure of foreign firms in an industry is positive and significant and its squared term is negative and significant across these models, consistently supporting Hypotheses 1 and 2. It is not surprising that the effect size of the entry tenure of foreign firms is smaller in models with longer lags ($b = 0.021, 0.007, 0.006,$ and 0.004 for 2-, 3-, 4-, and 5-year lags, respectively). Among the three moderating effects, the moderating effect of foreign firms' export intensity (Hypothesis 3) is the most robust and that of foreign firms' entry pattern rhythm (Hypothesis 5) is the least robust. Nevertheless, none of the moderating effects is supported in Model D, where a 5-year lag was used.

Supplementary Analysis VII: Using Random Sub-Samples

Considering our large sample size, we randomly drew 50, 20, and 10% of the domestic firms in our data and re-estimated our models. These analyses produced results highly consistent with those reported in this paper. For the sake of space, these additional results are not reported here, but are available from the authors upon request.

DISCUSSION AND CONCLUSIONS

Contributions to the FDI Spillover Literature

Our study was motivated by the desire to better understand how FDI spillovers may occur *over time* in an emerging market. It contributes to the literature by explicitly investigating the dynamics of the spillover process. As noted earlier, prior research has primarily taken a snapshot approach to examine how *FDI presence* (in terms of the share of FDI in an industry) affects domestic firms. While several studies have acknowledged that time is a

TABLE 5
Firm-Fixed Effect Models of Domestic Firm Production Function—Effects of Foreign Firms by Geographic Locations and Country Origins^{a,b}

Variables	Foreign Firms by Geographic Locations		Foreign Firms by Country Origins	
	Model A (within the region)	Model B (outside the region)	Model C (from HMT ^b)	Model D (from other countries)
Log <i>K</i>	0.364*** (0.002)	0.376*** (0.002)	0.373*** (0.002)	0.374*** (0.002)
Log <i>L</i>	0.369*** (0.003)	0.376*** (0.002)	0.378*** (0.002)	0.376*** (0.002)
Predictors				
Entry tenure of foreign firms in an industry	0.009*** (4.94E-04)	0.008*** (4.07E-04)	0.014*** (3.31E-04)	0.010*** (2.88E-04)
Export intensity of foreign firms	-0.073*** (0.005)	-0.029*** (0.004)	-7.03E-04 (0.003)	-0.024*** (0.004)
Intangible asset intensity of foreign firms	-0.401*** (0.030)	-0.031** (0.011)	-0.007 (0.008)	-0.121*** (0.017)
Rhythm of entry pattern of foreign firms	0.004*** (4.18E-04)	0.002*** (3.99E-04)	-7.00E-04 (4.00E-04)	1.46E-03*** (3.28E-04)
Interactions				
Squared term of entry tenure of foreign firms in an industry	-7.98E-04*** (1.12E-04)	-8.89E-04*** (8.80E-05)	-8.49E-04*** (6.48E-05)	-5.69E-04*** (5.23E-05)
Entry tenure of foreign firms in an industry × Export intensity of foreign firms	-0.008*** (1.53E-03)	-0.004*** (1.22E-03)	-0.004*** (8.95E-04)	-0.004*** (8.56E-04)
Entry tenure of foreign firms in an industry × Intangible asset intensity of foreign firms	-0.005 (0.011)	-0.012** (0.004)	-0.015*** (0.003)	-0.037*** (0.008)
Entry tenure of foreign firms in an industry × Rhythm of entry pattern of foreign firms	4.86E-05 (1.82E-04)	4.90E-04** (1.83E-04)	1.57E-04 (1.31E-04)	-1.64E-04 (1.19E-04)
Controls				
(All controls listed in Table 2 were included.)				
<i>F</i> value	1,460***	2,748***	2,707***	2,680***
Within <i>R</i> ²	0.2834	0.2845	0.2855	0.2872
Total <i>R</i> ²	0.9308	0.9151	0.9148	0.9135
<i>N</i> (firm-year observations)	638,185	937,013	917,982	896,967

^a Estimated coefficients and associated robust standard errors (in parentheses) are reported.

^b HMT refers to Hong Kong, Macau, and Taiwan.

* $p < .05$ (two-tailed tests)

** $p < .01$

*** $p < .001$

TABLE 6
Firm-Fixed Effect Models of Domestic Firm Production Function—Alternative Definitions of Domestic Firms and Foreign Firms^{a,b,c}

Variables	Domestic Firms, in Which Domestic Ownership is . . . ^b			Foreign Firms, in Which Foreign Ownership is . . . ^c		
	>95%	>80%	>75%	>95%	>80%	>75%
	Model A	Model B	Model C	Model D	Model E	Model F
Log K	0.379*** (0.002)	0.381*** (0.002)	0.381*** (0.002)	0.379*** (0.002)	0.378*** (0.002)	0.378*** (0.002)
Log L	0.382*** (0.003)	0.383*** (0.003)	0.384*** (0.003)	0.380*** (0.003)	0.381*** (0.003)	0.381*** (0.003)
Predictors						
Entry tenure of foreign firms in an industry	0.016*** (4.74E-04)	0.016*** (4.72E-04)	0.016*** (4.70E-04)	0.016*** (4.80E-04)	0.018*** (5.08E-04)	0.019*** (5.05E-04)
Export intensity of foreign firms	-0.050*** (0.005)	-0.050*** (0.005)	-0.050*** (0.005)	-0.049*** (0.005)	-0.056*** (0.005)	-0.068*** (0.005)
Intangible asset intensity of foreign firms	-0.029** (0.011)	-0.030** (0.011)	-0.031** (0.011)	-0.020 (0.011)	-0.076*** (0.013)	-0.050*** (0.014)
Rhythm of entry pattern of foreign firms	0.005*** (4.14E-04)	0.005*** (4.12E-04)	0.005*** (4.11E-04)	0.005*** (4.18E-04)	0.007*** (4.26E-04)	0.007*** (3.99E-04)
Interactions						
Squared term of entry tenure of foreign firms in an industry	-0.002*** (1.16E-04)	-0.002*** (1.15E-04)	-0.002*** (1.15E-04)	-0.002*** (1.19E-04)	-0.002*** (1.25E-04)	-0.003*** (1.25E-04)
Entry tenure of foreign firms in an industry × Export intensity of foreign firms	-0.006*** (1.50E-03)	-0.006*** (1.50E-03)	-0.006*** (1.49E-03)	-0.008*** (1.52E-03)	-0.013*** (1.65E-03)	-0.011*** (1.63E-03)
Entry tenure of foreign firms in an industry × Intangible asset intensity of foreign firms	-0.032*** (0.004)	-0.033*** (0.004)	-0.033*** (0.004)	-0.035*** (0.005)	-0.072*** (0.006)	-0.080*** (0.006)
Entry tenure of foreign firms in an industry × Rhythm of entry pattern of foreign firms	7.09E-04*** (2.18E-04)	7.36E-04*** (2.18E-04)	7.48E-04*** (2.17E-04)	6.35E-04** (2.23E-04)	0.001*** (2.44E-04)	7.97E-04*** (2.29E-04)
Controls						
(All controls in Table 2 were included.)	1,941***	1,968***	1,982***	1,983***	1,987***	1,991***
Within R^2	0.2665	0.2681	0.2685	0.2656	0.2658	0.2660
Total R^2	0.9310	0.9315	0.9317	0.9309	0.9309	0.9309
N (firm-year observations)	947,432	954,436	960,470	945,553	945,553	945,553

^a Estimated coefficients and associated robust standard errors (in parentheses) are reported.

^b In Models A–C, foreign firms referred to those with 100% foreign ownership.

^c In Models D–G, domestic firms referred to those with 100% domestic ownership.

* $p < .05$ (two-tailed tests)

** $p < .01$

*** $p < .001$

TABLE 7
Firm-Fixed Effect Models of Domestic Firm Production Function—Longer Lags^a

Variables	Model A	Model B	Model C	Model D
Log K	2-year lag 0.383*** (0.003)	3-year lag 0.383*** (0.003)	4-year lag 0.396*** (0.004)	5-year lag 0.412*** (0.004)
Log L	0.386*** (0.003)	0.422*** (0.004)	0.447*** (0.005)	0.462*** (0.006)
Predictors				
Entry tenure of foreign firms in an industry	0.021*** (5.46E-04)	0.007*** (6.36E-04)	0.006*** (8.12E-04)	0.004*** (0.001)
Export intensity of foreign firms	-0.046*** (0.005)	-0.013* (0.006)	0.003 (0.007)	-0.003 (0.009)
Intangible asset intensity of foreign firms	-0.002 (0.012)	0.028 (0.016)	0.013 (0.021)	-0.032 (0.036)
Rhythm of entry pattern of foreign firms	0.005*** (4.58E-04)	4.88E-06 (5.29E-04)	-0.001 (6.27E-04)	-9.81E-04 (7.48E-04)
Interactions				
Squared term of entry tenure of foreign firms in an industry	-0.002*** (1.35E-04)	-7.82E-04*** (1.45E-04)	-8.69E-04*** (1.91E-04)	-3.66E-04 (2.28E-04)
Entry tenure of foreign firms in an industry × Export intensity of foreign firms	-4.55E-03** (1.75E-03)	-0.007*** (1.90E-03)	-0.011*** (2.34E-03)	-0.001 (2.96E-03)
Entry tenure of foreign firms in an industry × Intangible asset intensity of foreign firms	-0.017*** (4.58E-03)	-0.004 (0.005)	-0.017*** (0.006)	0.002 (0.007)
Entry tenure of foreign firms in an industry × Rhythm of entry pattern of foreign firms	-1.70E-04 (2.51E-04)	5.73E-04* (2.85E-04)	3.21E-04 (3.45E-04)	-2.97E-04 (4.02E-04)
Controls				
(All controls in Table 2 were included.)				
F value	1,079***	1,919***	1,362***	1,196***
Within R ²	0.2439	0.3436	0.3690	0.4072
Total R ²	0.9397	0.9088	0.9059	0.9030
N (Firm-year observations)	644,208	423,281	259,457	167,204

^a Estimated coefficients and associated robust standard errors (in parentheses) are reported.

* $p < 0.05$ (two-tailed tests)

** $p < 0.01$

*** $p < 0.001$

relevant dimension in assessing FDI spillovers (e.g., De Backer & Sleuwaegen, 2003; Spencer, 2008), ours is the first one that directly examined the role of time in FDI spillovers. Using a comprehensive panel dataset of manufacturing firms in China in 1998–2007, we found that the entry tenure of foreign firms in an industry had a positive relationship with the productivity of individual domestic firms in the industry, and this positive relationship became weaker as the entry tenure of the foreign firms continued to increase. These results were further validated by using domestic firms' survival as an alternative outcome variable. Our findings suggest that it is not just the presence of foreign firms but also the entry tenure of the foreign firms that affects their spillovers to domestic firms. Our results also suggest that there may be a limit on the extent to which FDI spillovers occur over time because obvious opportunities for domestic firms to learn would gradually dry up.

We further drew upon the competitor imitation argument (Lippman & Rumelt, 1982; Reed & DeFilippi, 1990) to examine how the role of time in FDI spillovers may depend upon the *imitability* of the foreign firms. We found that the positive relationship between the entry tenure of foreign firms in an industry and the productivity of individual domestic firms in the industry was stronger when the foreign firms had lower export intensity, lower intangible asset intensity, and had followed a more rhythmic entry pattern—attributes that are associated with lower barriers to imitation. These results are consistent with our argument that the role of time in FDI spillovers depends upon the height of barriers of imitation faced by the domestic firms: the lower the barriers, the greater the effect of time in FDI spillovers. While not hypothesized, we found that the three moderating variables had direct relationships with the productivity of individual domestic firms—export intensity and intangible assets intensity of foreign firms had significantly negative relationships, and the rhythm of their entry pattern had a significantly positive relationship.

Our focus on the role of time in FDI spillovers differs from and yet complements some recent research efforts in this area. Chang and Xu (2008) separated FDI presence at the national level and at the regional level. They found that FDI presence at the national level increased the survival rate of domestic firms while FDI presence at the regional level reduced the survival rate of domestic firms. Zhang et al. (2010) focused on the diversity of country origins of foreign firms in an industry and

found that it had a significantly positive relationship with the productivity of domestic firms in the industry. These studies advanced the literature by examining the (intra-temporal) heterogeneous nature of FDI. In contrast, our study dealt with the *inter-temporal* aspect of FDI spillovers. Our findings show that, as the entry tenure of foreign firms in an industry increased, domestic firms in the industry improved their productivity/increased their survival rate (albeit at a diminishing rate), and this effect varied across industries, depending upon the imitability of the foreign firms. Our inter-temporal approach added an important new dimension to FDI spillover research, and should encourage further research in this direction.

Moreover, our focus on the contingent effects of foreign firms' attributes also differs from and complements recent studies in this area. Recognizing the importance of domestic firms as knowledge recipients in the FDI spillover relationship, recent studies have examined how attributes of domestic firms—particularly, their motivation and ability to learn—can affect the extent to which they can benefit from FDI spillovers (e.g., Sjöholm, 1999; Zhang et al., 2010). However, foreign firms, as the knowledge source firms in the FDI spillover relationship, have been largely treated as “black boxes” (Spencer, 2008). Our results suggest foreign firms' attributes—that is, their export intensity, intangible asset intensity, and the rhythm of their entry pattern—affected the *speed* with which FDI spillovers occur. These attributes of foreign firms also had direct relationships with the productivity of domestic firms. Our study and other recent studies in the area jointly demonstrate that we need to consider the attributes of both foreign firms and domestic firms in order to better understand how spillovers occur between them.

Practical Implications

Our findings have important implications for MNC managers, domestic managers, and policy makers in emerging markets. For MNC managers, our findings help them better understand how domestic firms in the host country learn from them over time, and under what conditions they are more or less vulnerable to domestic imitation. As noted in a recent report issued by the Economist Intelligence Unit (2011: 4): “It is often taken as fact that multinationals have superior technology and better brand management. . . . There are signs that all of these advantages are beginning to erode in China.” Our findings suggest

that, while domestic firms are catching up over time, the speed of catching up varies across industries—the speed is slower in industries with higher levels of imitation barriers.

For domestic managers in emerging markets, our findings send a clear message to them that benefits of FDI spillovers take time to materialize, and there is also a limit on the extent to which domestic firms can learn from foreign firms over time. Figure 1 illustrates that, as entry tenure of foreign firms in an industry reaches two to three standard deviations above its sample mean (about 10–12 years), the slope becomes close to being flat. These results suggest that 10–12 years is a reasonable time frame for FDI spillovers, after which domestic firms' additional productivity gains through learning from foreign firms would be limited. Our findings also suggest that domestic firms need to find the right "targets" for learning: foreign firms with local market focus and those with high tangible assets intensity are relatively easier to imitate.

Our results also provide suggestions for policy makers in emerging markets on how to manage the process of FDI inflow in order to maximize FDI spillovers. Bringing in FDI at a more rhythmic pace enables domestic firms to better observe and understand foreign entrants' technologies, and, thus, to benefit more from FDI spillovers. Also, governments of emerging markets very often pressure foreign firms to export because export growth is usually closely associated with the economic development of emerging markets. Our results demonstrate that foreign firms' export may delay the speed with which domestic firms learn from the foreign firms. Thus, policy makers need to take into account the potential learning benefits of domestic firms when making their FDI policies.

Limitations and Future Research Directions

This study has some limitations that offer fruitful opportunities for future research in this area. First, we examined the role of time in FDI spillovers by focusing on the entry tenure of foreign firms in an industry. Our findings provide an overall picture of how foreign firms' spillovers to domestic firms occur over time. Future studies may examine more specific dimensions of time; for example, time elapsed since some milestone events related to FDI. One possible milestone event is a significant investment in an industry made by a major MNC. Such an investment signals the potential of the industry in the host country, which will attract

attention from both foreign firms and domestic firms to this sector. Also, considering the importance of local suppliers in FDI spillovers, when foreign firms started to purchase from local suppliers (or when their overseas suppliers were relocated to the host country) may be another milestone event.

Second, we examined three attributes of foreign firms that may affect barriers to imitation; future research may examine other sources of barriers to imitation. One possible direction is to look at foreign firms' strategic alliances with domestic firms. Foreign firms' knowledge transferred to their domestic partners may be further passed to domestic non-partner firms, with the domestic partners acting as mediating channels (Spencer, 2008). Thus, to the extent that foreign firms in an industry are prone to forming strategic alliances with domestic firms, the barriers to imitation may be much reduced.

Third, we focused on FDI spillovers in China; the question of whether our findings are generalizable to other emerging markets remains unanswered. We believe that the core ideas that FDI spillovers tend to occur over time (at a diminishing rate) and that the attributes of foreign firms may affect the role of time are applicable to other emerging markets. Emerging markets, however, are different along many dimensions, including the maturity of economic growth, institutional stability, and the level of protection of property rights and contract enforcement (Hitt et al., 2005). Compared to other emerging markets, such as Romania, Kenya, and Ecuador, China has some unique attributes, including strong industrial policy, government ownership, and enormous internal markets. Yet, how to attract FDI and to facilitate FDI spillovers represent major policy challenges for many emerging markets. Future research should replicate our study with firms in other emerging markets. Such research effort cannot only add to our knowledge on FDI spillovers, but also provide valuable practical suggestions on how emerging market countries can develop their economies by using FDI.

In conclusion, to the best of our knowledge, this is the first empirical study that explicitly examines how foreign firms' spillovers to domestic firms may occur over time in an emerging market and how foreign firms' attributes may affect the effect of time in the spillover process. Our findings can contribute to a better understanding of the dynamics of FDI spillovers and should stimulate future research effort to focus on this emerging and interesting research topic.

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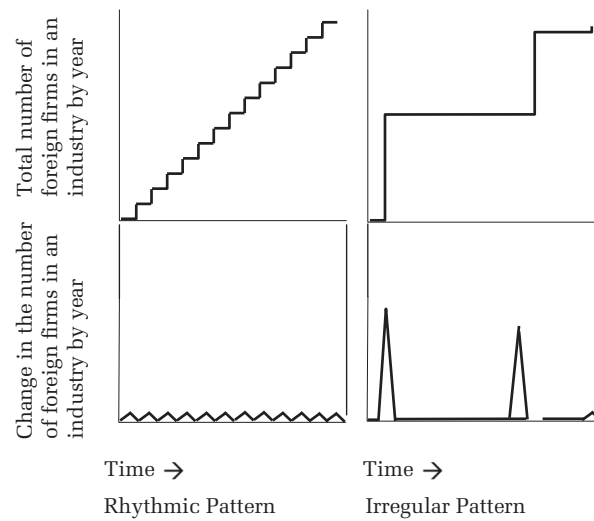
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APPENDIX A
Rhythmic vs. Irregular Patterns of Foreign Firms' Entries



Note: We created this illustration based upon Vermeulen and Barkema's (2002: 642) Figure 1, which compared rhythmic and irregular patterns of firms' internationalization processes.

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