China & World Economy / 24–48, Vol. 29, No. 2, 2021

Productivity Gap and Inward FDI Spillovers: Theory and Evidence from China

*Jim Huangnan Shen, Hao Wang, Steve Chu-Chia Lin**

Abstract

This paper constructs a two-stage sequential game model to shed light on the spillover effect of inward FDI on the efficiency of domestic firms in host countries. Our model shows that, given an optimal joint-venture policy made by foreign firms, the impact of the spillover effect of inward FDI is contingent upon the productivity gap between the domestic firms and foreign ones. In particular, we demonstrate that the spillover effect of inward FDI varies negatively with the productivity gap between domestic low-productivity firms and foreign firms but works in the opposite way for high-productivity firms. This suggests that once the productivity gap widens, the entry of foreign firms will increase the efficiency of high-productivity firms but reduce the efficiency of low-productivity firms. In support of our theoretical model, we provide robust empirical results by using the dataset of annual survey of Chinese industrial enterprises.

Key words: efficiency improvement, inward FDI, productivity gap, spillover effect
JEL codes: F21, L10, O40

I. Introduction

In recent decades there has been ongoing research on how far the spillover effect of FDI contributes to the economic growth of host countries. Focusing on China, the world's largest emerging economy, some maintain that the dramatic growth and the improved competitiveness of the domestic industrial capability of the Chinese economy since the opening-up policy have been attributable to the massive scale of inward FDI (e.g. Zhang, 2001; Yao, 2006; Lin et al., 2013; Chen and Wu, 2017). Others, however, contend that the impact of FDI on local economic growth for the

*Jim Huangnan Shen, Assistant Professor, School of Management, Fudan University, China and Center for International Development, Harvard Kennedy School, US. Email: hnshen@fudan.edu.cn; Hao Wang (corresponding author), Lecturer (Yunshan Scholar), School of Economics and Trade, Guangdong University of Foreign Studies, China and School of Slavonic and East European Studies, University College London, UK. Email: hao-wang@ucl.ac.uk; Steve Chu-Chia Lin, Professor, Department of Economics, National Chengchi University, Taiwan, China. Email: cclin008@gmail.com.

Chinese economy appears to be inconclusive (e.g. Lee and Chang, 2009; Buckley et al., 2010). Indeed, as argued by Javorcik (2004), FDI can exert a positive spillover effect on the local industrial enterprises if and only if the multinational firms form joint ventures with domestic ones and are not fully owned foreign investments. Moreover, Rodrik (1999) argues that a higher level of productivity in domestic firms producing for export does not necessarily imply that they have received any technology spillover from foreign firms, because most productive firms, whether domestic or foreign ones, tend to specialize in their export sectors.

What sets the present paper apart from these works is that we provide a new angle in terms of assessing the degree to which FDI could improve the productivity of local industrial enterprises through the spillover effect. We demonstrate, with a theoretical model, that, given an optimal joint-venture policy from foreign firms, the impact of the spillover effect of inward FDI is contingent upon the productivity gap between the domestic firms and foreign ones. In particular, we have found that the spillover effect of inward FDI varies negatively with the productivity gap between low-productivity domestic firms and foreign firms and the opposite holds true for high-productivity domestic firms. Our results suggest that once the productivity gap widens, the entry of foreign firms will increase the efficiency of high-productivity firms and reduce the efficiency of low-productivity firms.

The contributions of this paper are twofold: theoretical and empirical. Although many works that address the issues of FDI have documented robust evidence of its technology spillovers to host countries (Blomstrom and Kokko, 1998; Sjoholm, 1999; Görg and Greenaway, 2004), theoretical work illustrating the technology spillover effect of FDI has been largely neglected in the literature. Baldwin et al. (2005) and Liu (2008) propose a theoretical framework to study the spillover effect of FDI, but there are two apparent weaknesses in their framework. First, both of their models are based on endogenous growth theory, which does not manage to reveal the micro-mechanism, that is, the dynamics of firm-level productivity improvement of such technology spillover from FDI. The only thing that can be learned from their models is that the technology spillover from FDI leads to long-run economic growth in host countries, and there is no role in these models for the analysis of firm-level productivity dynamics. Second, due to the inability of these models to describe firm-level productivity, there is obviously no role for the heterogeneous firm framework in terms of analyzing the spillover effect in the host countries. The absence of the heterogeneous firm framework easily leads to the misconception that technology spillovers will always induce firms' productivity in the host countries to improve and that the anti-efficiency implications of the technology spillovers, such as the crowding-out effect resulting from the entry of multinational firms, will be ignored.

To better understand the FDI spillover effect, we construct a two-stage sequential game model. Drawing on previous studies (Javorcik, 2004; Lu et al., 2017), our theoretical model indicates that the share of foreign capital plays an essential role in affecting the productivity of firms. We allow two types of firms to differ in productivity, which directly affects their cost level. At the first stage of the game, the foreign firms choose the optimal joint-venture policies by deciding the optimal amount of shares they own in each of these two firms. At the second stage, after observing the optimal joint-venture policies from foreign firms, the high- and low-productivity firms engage in Cournot competition and decide their respective optimal output. When we solve this game backwards, we can implement comparative statistical analysis on the optimal functional trajectory of the joint-venture policies devised by the foreign firms in the first stage, which in turn enables us to find the relationship between the spillover effect parameter and the productivity gap parameter in the model.

In examining our theoretical model, we adopt a comprehensive firm-level analysis based on the Chinese Industrial Enterprises database from 2005 to 2013. To preview the findings, we first demonstrate that the share of foreign capital has a positive effect on productivity. When classifying the FDI into two types according to its origins, namely, Hong Kong–Macau–Taiwan capital (HMT) and foreign capital (all foreign capital excluding those from the HMT), we find that the positive effect of HMT capital still holds but is economically weaker. To further test our theoretical model, we distinguish high-productivity firms from low-productivity firms in sector-specific estimates. We then find that FDI increases output in high-productivity domestic firms while it reduces the output in low-productivity firms, which supports the main propositions in our theoretical model. Further, we find that state-owned enterprises are less productive than their counterparts but this is altered when they are in cooperation with foreign and HMT capital.

The rest of the paper is organized as follows. Section II reviews the relevant literature. Section III sets up a two-stage sequential game model followed by the solutions. Section IV introduces empirical strategy by outlining the data and deriving the empirical model. Section V concludes.

II. Literature review

This paper stands at the intersection of three streams of literature. The first addresses the impact of FDI spillovers on local economic growth in the host countries. The second concerns the effect of FDI spillovers on firm-level productivity in the host countries. The third is discussion on the inherent connection between FDI spillovers and the degree of absorptive capacity of domestic firms in the host countries.

1. FDI spillovers and economic growth

Regarding inward FDI spillovers and their impact on local economic growth, several works are worth mentioning. The papers by Zhang (2001), Yao (2006), Whalley and Xin (2010), and Chen (2015) all agree that inward FDI in China contributes substantially to regional economic growth. The weakness of this line of research is that they tend to ignore the micro-mechanism of such pro-growth implications of inward FDI, which is firm-level productivity enhancement. What sets this paper apart from these works is that we focus not on the macro-level economic growth implication of inward FDI but on the way in which FDI inward spillovers can affect the productivity of domestic firms in the host countries. The advantage of demystifying firm-level productivity dynamics affected by the inward FDI spillovers is that paying attention only to the macro-growth implications of inward FDI may neglect the crowding-out effect. The crowding-out effect inevitably leads to anti-growth implications for the host countries because the domestic firms cannot compete with the entry of multinational firms. Although the paper by Zhang (2001) suggests that the pro-growth effect of inward FDI in China is much stronger in the coastal regions than the inland ones, his paper investigates only the heterogeneous effect of inward FDI spillovers at the regional level. This paper goes one step further, arguing that such a heterogeneous effect at the regional level is actually caused by the productivity differentials of firms in different regions. The reason why the spillover effect is weaker in inland regions is that more low-productivity firms are concentrated there and they could be easily crowded out by the entry of more technologically advanced multinational firms. Furthermore, although Yao and Wei (2007) contend that inward FDI could narrow the technical efficiency gap between the domestic firms and multinational firms, their paper ignores the gap among the domestic firms. The latter gap, from our point of view, could be more useful in terms of assessing the true effect of inward FDI spillover on the productivity of domestic firms in host countries.

2. FDI spillovers and firm-level productivity

This paper contributes directly to the discussion concerning the relative efficacy of spillover effect of inward FDI on the productivity improvement of domestic industrial enterprises in the host countries in the literature. The earliest work on the benefits of inward FDI on the productivity of domestic firms in host countries is the one by Caves (1974), arguing that the positive spillover effect of inward FDI on the domestic firms comes from three sources. One is allocative efficiency, where the entry of multinational firms may pare down monopolistic distortions and raise the productivity of the host-country's resources by improving their allocation. The second source of gains of inward FDI is from the technical efficiency. This is because the subsidiary may induce a higher level of technical or X-efficiency in home-owned firms that compete with it and this might be caused by the multinational firm's competitive force or demonstration effect in an imperfectly competitive market. The third source of gains comes from the technological transfer. This refers to the ideas that the subsidiary may speed the transfer of technology and innovation causing it to transfer advanced technology to domestic firms, which in turn enhances the productivity level of these firms. What sets our paper apart from this work is that we demonstrate in a dynamic game that the degree of technological transfer is actually endogenous to the technical efficiency distribution of domestic firms. Hence, one cannot isolate the degree of technological transfer from the technical efficiency implications of domestic firms in the host countries.

Globerman (1979) examines the indirect economic benefits of inward FDI using a sample of Canadian manufacturing industries. He found that the amount of foreign ownership in an industry is strongly positively related to the labor productivity of domestic firms, indicating that inward FDI could economically benefit the labor productivity of domestic firms. The difference between our work and theirs is that we argue that the economic benefit of inward FDI has a heterogeneous effect on the labor productivity improvement of domestic firms, meaning that only firms with high productivity would receive the positive spillover effect of inward FDI whereas those with low productivity would be crowded out by multinational firms.

Liu et al. (2000) investigate intra-industry productivity spillovers from FDI in the UK manufacturing sector. They found that the very presence of FDI has a positive spillover impact on the productivity of UK-owned firms and the degree to which the local firms benefitted from the introduction of such advanced technology largely depended upon the domestic firms' technological capabilities. Our paper is closely linked with the idea developed in the above paper that the extent to which the inward FDI could benefit the efficiency enhancement of domestic firms is contingent upon the productivity of these domestic firms. However, our paper goes one step further to demonstrate that the relative productivity differences across domestic firms, rather than the absolute productivity level of domestic firms, are crucial for understanding the heterogeneous spillover effect of inward FDI on firms in host countries.[1]

Several other works that consider the spillover effect of inward FDI in developing countries are also worth mentioning. For example, early works by Kokko (1996) and Sjoholm (1999) support the view that inward FDI has a positive spillover effect on

[1]The empirical findings by Flores et al. (2007) are consistent with the argument in our paper. They find that the technological differences and factor intensity differences across industries in host countries are the two key forces determining the direction of the spillover effect of inward FDI. However, they do not analyze this at the firm level.

domestic firms from developing countries, whereas others including Kokko et al. (1996) and Aitken and Harrison (1999) refuted the idea of a positive spillover effect of inward FDI on domestic firms from developing countries. In particular, Hu and Jefferson (2002) considered a sample of firms from Chinese textile industries and found that there was no positive spillover effect of inward FDI on Chinese textile firms. It can be seen that all these works, regardless of the degree of support for the existence of the positive spillover effect of inward FDI on firms from emerging economies, ignore the view that inward FDI ought to have a heterogeneous spillover effect on domestic firms in emerging economies, with particular reference to productivity differences between domestic firms. Our paper is one of the first in the literature to describe this channel. In particular, our theoretical model indicates that a lower threshold for the productivity gap among domestic firms ought to exist and that the firms whose productivity falls below this threshold will receive a negative spillover effect.

3. FDI spillover and absorptive capacity

Our paper is also closely associated with another stream of FDI literature, which concerns the absorptive capacity of domestic firms in the FDI host countries. The papers by Fu (2008) and Farole and Winkler (2012) maintain that the availability of the absorptive capacity largely determines the strength of positive spillover effect of inward FDI on overall regional capacity to innovate. Although they indicate the role of absorptive capacity in determining the relative efficiency of the spillover effect of inward FDI, it does not link the concept of absorptive capacity to different levels of productivity distribution across domestic firms in host countries. We argue that firms with different levels of productivity will have distinct levels of absorptive capacity to receive inward FDI and high-productive firms apparently have a higher absorptive capacity for transferring knowledge from technologically more advanced multinational firms.

Two papers that are mostly closely in line with the spirit of our paper are by Chen et al. (2010) and Xu and Sheng (2012), who argue that industries with high absorptive capacity or high efficiency levels are the best equipped to take advantage of spillovers from foreign-owned firms. Our paper differs from theirs in two respects: first, they consider only the heterogeneous effect of inward FDI spillovers at industry level, whereas both the theoretical model and empirical evidence in our paper show that such a heterogeneous effect also holds at the firm level. Second, our paper shows that the firms with low productivity (low absorptive capacity) will also receive a negative spillover effect, a consequence which their paper fails to take into account. Even so, the paper by Hale and Long (2006) illustrates a similar argument regarding the effect of inward FDI spillovers and the way in which they will be affected by technological productivity differences across domestic firms, but their paper fails to produce a theoretical model. Moreover, their empirical results do not incorporate different sources of FDI, which could also reflect the heterogeneous effect of inward FDI spillovers on the productivity of domestic firms. That is to say, the FDI spillovers from medium-productivity firms and from high-productivity firms, due to the distinct technological gap between theirs and domestic firms, will reveal different effects.

III. A two-stage sequential game model

1. Set up

We consider a market that consists of two types of firms. One type of firms is highly productive and the other less productive. These two types of firms operate in the market with an inverse demand function given by $p = 1 - Q$, where p is the market price and $Q = q_H + q_L$ is the total output in the market, q_H is the output for the high-productivity firms, and q_L is the output for low-productivity firms. The cost function for the high-productivity firms is in the following quadratic form: $C_H = \frac{S_H k_H (q_H)^2}{2}$. Likewise, the cost function for the low-productivity firms is $C_L = \frac{S_L k_L (q_L)^2}{2}$, where k_H and k_L are respectively the technological coefficients for high and low-productivity firms. It is assumed that $k_L > k_H$. S_H and S_L are, respectively, the coefficients of spillovers of high- and low-productivity firms. It is assumed here that $S_H \in [0, +\infty)$ and $S_L \in [0, +\infty)$. When $S_i = 0$, there is a fully positive spillover effect. When $S_i = +\infty$, there is a fully negative spillover effect. The rationale behind this is that the spillover effect directly enters into the cost function of each type of firms. When $S_i = 0$, the firms' costs vanish because the spillover effect is the largest in this case, which is a reflection of productivity improvement. Conversely, when $S_i = +\infty$, the cost level for each type of firms becomes large, indicating that the firms are not viable and will easily be crowded out by the multinational firms. We also assume that there are several factors, which have been widely discussed in the literature, that might affect the technological spillover, regardless of whether it is positive or negative, between more productive multinational firms and the low-tech domestic firms. These factors include joint ventures, the pooling of the labor market, the input–output linkage, CEO turnover, and geographical concentration (Javorcik, 2004; Lu et al., 2017; and others).

Given the multiple factors affecting the extent of technological spillover, it is assumed in this paper that the general function form of the technology spillover for the domestic high-productivity firms and low-productivity firms is defined as shown in Equations (1) and (2):

$$S_H = f(\alpha_H, L_H, I_H, C_H, G_H), \tag{1}$$

$$S_L = g(\alpha_L, L_L, I_L, C_L, G_L), \tag{2}$$

where α_i, L_i, I_i, C_i, and G_i are the respective parameters standing for the level of joint-venture shares, the pooling of labor market, the input-output linkage, CEO turnover, and geographical concentration for the high-productivity and low-productivity firms, where $i = H, L$.[2] The other way to interpret these two general function forms of the technology spillover is that these determinants of the spillover are representative of the means the foreign firms adopt to enhance their competitiveness including profitability and productivity in the domestic market. The profit function of the high-productivity firms thus can be expressed as in Equation (3):

$$\pi_H = S_H[(1-Q)q_H - \frac{S_H k_H (q_H)^2}{2}]. \tag{3}$$

The profit function of low-productivity firms is therefore written as in Equation (4):

$$\pi_L = S_L[(1-Q)q_L - \frac{S_L k_H (q_L)^2}{2}]. \tag{4}$$

Furthermore, suppose the cost function for the foreign firms can be expressed as $C_f = \frac{k_f (q_H + q_L)^2}{2}$, where $k_H = \beta k_f$ and $\beta \in [1,+\infty)$. This captures the technological gap between foreign firms and domestic firms with high and low productivity.

Hence, the aggregate profit function, which is maximized by the foreign firms, can be stated as in Equation (5):

$$\begin{aligned} \Pi = {} & f(\alpha_H, L_H, I_H, C_H, G_H)[(1-Q)q_H - \frac{S_H k_H (q_H)^2}{2}] \\ & + g(\alpha_L, L_L, I_L, C_L, G_L)[(1-Q)q_L - \frac{S_L k_L (q_L)^2}{2}] - \frac{k_f (q_H + q_L)^2}{2}. \end{aligned} \tag{5}$$

From Equation (5), it could be observed that there are two channels through which

[2]In the later empirical section we adopt the degree of joint venture as the representative of entry mode and as the means by which the foreign firms adapt to determine their optimal strategies, which could induce the technological spillover. Although there are other modes of entry, for the tractability of the model, we only consider the joint venture case here. According to Whalley and Xin (2010), most foreign invested enterprises are joint ventures of foreign firms and their Chinese counterparts, and they could be deemed to form a distinct subpart of the Chinese economy. The treatment of joint ventures as the typical entry mode of FDI is therefore reasonable and justified. See also Wang et al. (2020a) for comparisons between joint ventures and other forms of FDI in China over recent years.

the technological spillover might affect the economic performance of high- and low-productivity domestic firms. First, as argued previously, the degree of technological spillover could affect the cost level of domestic firms. The higher level of positive spillover could apparently induce the cost reduction of these firms. Second, the degree of technological spillover might also affect the profitability level of firms. The higher level of positive spillover could also enhance the rise in profitability of firms and vice versa for the lower level of spillover effect. The stages of this two-stage sequential game are defined as follows:

Stage 0. The foreign firms choose one of the determinant strategies of technology spillover (α_i, L_i, I_i, C_i or G_i) through owning the shares of domestic firms including both high- and low-productivity ones to maximize their aggregate profitability.

Stage 1. After observing the foreign firms' optimal technological spillover strategies, high- and low-productivity firms compete in a Cournot quantity game and they choose their optimal level of output, respectively.

2. Solution

We solve this dynamic game by backward induction. We start from the second stage of the game. Suppose the high-productivity and low-productivity firms play Cournot in quantity competition: the profit maximization problem for the high-productivity firms could be illustrated as in Equation (6):

$$\underbrace{Max}_{q_H} = S_H[(1-q_H-q_L)q_H - \frac{S_H k_H (q_H)^2}{2}]. \tag{6}$$

Solving for Equation (6) and taking its derivative with respect to q_H, we obtain the best response function for the high-productivity firms, shown in Equation (7):

$$Q_H = \frac{1+q_L}{S_H k_H + 2}. \tag{7}$$

Likewise, the profit maximization problem for the low-productivity firms is as follows:

$$\underbrace{Max}_{q_L} = S_L[(1-q_H-q_L)q_L - \frac{S_L k_L (q_L)^2}{2}], \tag{8}$$

$$Q_L = \frac{1+q_H}{S_L k_L + 2}. \tag{9}$$

On the basis of Equations (7) and (9), we can compute the equilibrium level of output for high- and low-productivity firms:

$$\begin{cases} q_H^* = \dfrac{S_L k_L + q_H + 3}{(2+S_L k_L)(2+S_H k_H)} \\ q_L^* = \dfrac{S_H k_H + q_L + 3}{(2+S_H k_H)(2+S_L k_L)} \end{cases}. \tag{10}$$

Given Equation (10), we can compute the equilibrium profits of both high- and low-productivity domestic firms:

$$\begin{cases} \pi_H^* = S_H\left[\left(1-\dfrac{S_L k_L+q_H+3}{(2+S_L k_L)(2+S_H k_H)}-\dfrac{S_H k_H+q_L+3}{(2+S_H k_H)(2+S_L k_L)}\right)\dfrac{S_L k_L+q_H+3}{(2+S_L k_L)(2+S_H k_H)}-\dfrac{S_H k_H}{2}\left(\dfrac{S_L k_L+q_H+3}{(2+S_L k_L)(2+S_H k_H)}\right)^2\right] \\ \pi_L^* = S_L\left[\left(1-\dfrac{S_L k_L+q_H+3}{(2+S_L k_L)(2+S_H k_H)}-\dfrac{S_H k_H+q_L+3}{(2+S_H k_H)(2+S_L k_L)}\right)\dfrac{S_H k_H+q_L+3}{(2+S_H k_H)(2+S_L k_L)}-\dfrac{S_L k_L}{2}\left(\dfrac{S_H k_H+q_L+3}{(2+S_H k_H)(2+S_L k_L)}\right)^2\right] \end{cases}. \tag{11}$$

At the first stage of the game, after observing the equilibrium output of high- and low- productivity firms implied by Equation (10), the foreign firms optimally choose one of the determinant strategies of technology spillover (α_i, L_i, I_i, C_i *or* G_i) through respectively owning the shares of domestic firms including both high- and low-productivity ones to maximize their aggregate profitability. Plugging Equation (11) into the aggregate profit function of foreign firms, we obtain the following:

$$\Pi = S_H[\pi_H^*(S_H,S_L)] + S_L[\pi_L^*(S_H,S_L)] - \frac{k_f(q_H^*+q_L^*)^2}{2}. \tag{12}$$

We differentiate Equation (12) with respect to one of the determinant strategies of technology spillover among α_i, L_i, I_i, C_i, and G_i and make it equal to zero, thus deriving the optimal technological spillover trajectories for both high- and low-productivity firms:

$$\begin{cases} \dfrac{\partial S_H}{\partial f}\left[\pi_H^*(S_H,S_L)\right] + S_H\left[\dfrac{\partial \pi_H^*}{\partial S_H}\dfrac{\partial S_H}{\partial f}\right] + S_L\left[\dfrac{\partial \pi_L^*}{\partial S_H}\dfrac{\partial S_H}{\partial f}\right] = k_f Q^*\dfrac{\partial Q^*}{\partial f}, f = \alpha_H, L_H, I_H, C_H \text{ or } G_H \\ \dfrac{\partial S_L}{\partial g}\left[\pi_L^*(S_H,S_L)\right] + S_H\left[\dfrac{\partial \pi_H^*}{\partial S_L}\dfrac{\partial S_L}{\partial g}\right] + S_L\left[\dfrac{\partial \pi_L^*}{\partial S_L}\dfrac{\partial S_L}{\partial g}\right] = k_f Q^*\dfrac{\partial Q^*}{\partial g}, g = \alpha_L, L_L, I_L, C_L \text{ or } G_L \end{cases}, \tag{13}$$

where $Q^* = q_H^* + q_L^*$, $k_H = \beta k_f$, and $\beta \in [1,+\infty)$.

For the first part of Equation (13), which represents the optimal functional trajectory of the optimal technological spillover by foreign investors in both high- and low-productivity firms, using the implicit function theorem, we can compute how the S_H and S_L varies with the productivity gap parameter β:

$$\begin{cases} \dfrac{\partial S_H}{\partial \beta} = \dfrac{\partial S_H}{\partial f}\dfrac{\partial f}{\partial \beta} \\ \dfrac{\partial S_L}{\partial \beta} = \dfrac{\partial S_L}{\partial g}\dfrac{\partial g}{\partial \beta} \end{cases}, \tag{14}$$

where $\frac{\partial S_H}{\partial f}=\frac{k_f Q^* \frac{\partial Q^*}{\partial f}}{\pi_H^*(S_H,S_L)+S_H\left(\frac{\partial \pi_H^*}{\partial S_H}\right)+S_L\left(\frac{\partial \pi_L^*}{\partial S_H}\right)}$, $\frac{\partial S_L}{\partial g}=\frac{k_f Q^* \frac{\partial Q^*}{\partial g}}{\pi_L^*(S_H,S_L)+S_H\left(\frac{\partial \pi_H^*}{\partial S_L}\right)+S_L\left(\frac{\partial \pi_L^*}{\partial S_L}\right)}$.

From Equation (14), for the high-productivity firms, it is known that there are three key terms that are crucial for determining the sign of $\frac{\partial S_H}{\partial f}$, which are $\frac{\partial Q^*}{\partial f}$, $\frac{\partial \pi_H^*}{\partial S_H}$ and $\frac{\partial \pi_L^*}{\partial S_H}$. For $\frac{\partial Q^*}{\partial f}$, as it is apparently known that the adoptions of the technological spillover policies including joint venture, pooling of labor market CEO turnover and so on could enlarge the market size and boost the aggregate demand of the FDI host country as a whole, it is reasonable to assume $\frac{\partial Q^*}{\partial f}>0$. Second, in terms of $\frac{\partial \pi_H^*}{\partial S_H}$, it could also be demonstrated that the higher positive degree of spillover over high-productivity firms (lower value of S_H) will lead to the lower value of equilibrium profitability of high-productivity firms. Thus, it implies that $\frac{\partial \pi_H^*}{\partial S_H}<0$. In contrast, with respect to $\frac{\partial \pi_L^*}{\partial S_H}$, the lower value of S_H will lead to the higher equilibrium value of low-productivity firms, therefore demonstrating the positive sign of $\frac{\partial \pi_L^*}{\partial S_H}$. However, it is reasonable to assume that the positive effect of $\frac{\partial \pi_L^*}{\partial S_H}$ is strictly dominating that of the negative effect of $\frac{\partial \pi_H^*}{\partial S_H}$ because of the existence of a crowding-out effect in terms of the capturing of higher market share for low-productivity firms over the high-productivity ones. In other words, the positive value of $\frac{\partial \pi_L^*}{\partial S_H}$ is strictly larger than the absolute value of $\frac{\partial \pi_H^*}{\partial S_H}$. Overall, it could be deduced that $\frac{\partial S_H}{\partial f}>0$. Likewise, analogous to the case of the high-productivity firms, it is obvious that $\frac{\partial S_L}{\partial g}>0$.

In terms of $\frac{\partial f}{\partial \beta}$ and $\frac{\partial g}{\partial \beta}$, from the viewpoint of the foreign firms, when the productivity differentials between the high- and low-productivity firms enlarge, they are apparently more likely to adopt the spillover enhancing strategies on high-productivity firms instead of low ones. Hence, $\frac{\partial f}{\partial \beta}>0$ and $\frac{\partial g}{\partial \beta}<0$. Hence, the following propositions in this paper could be derived as follows:

Proposition 1: Given the optimal technological spillover policy imposed upon high-productivity firms, when the productivity gap between foreign firms and domestic firms becomes larger, the positive spillover effect of inward FDI on high-productivity firms is correspondingly larger), namely

$$\frac{\partial S_H}{\partial \beta} > 0 . \tag{15}$$

Proposition 2: Given the optimal technological spillover policy imposed upon low-productivity firms, when the productivity gap between foreign firms and domestic firms becomes smaller, the positive spillover effect of inward FDI on high-productivity firms is correspondingly smaller, namely

$$\frac{\partial S_L}{\partial \beta} < 0 . \tag{16}$$

Propositions 1 and 2 imply that when the productivity of domestic firms (high-productivity firms) is closer to the world productivity frontier, which is indicated by the productivity of foreign firms, they will experience positive spillover effect from the entry of foreign firms. These high-productivity firms with a high level of absorptive capacity can easily absorb the most advanced knowledge and technology from the foreign firms because they are closer to the world technological frontier. Another possible explanation is that, comparatively, high-productivity firms are more (human) capital intensive and they are more technology driven and innovation oriented than the low-productivity firms. The larger productivity gap therefore reveals a greater room for improvement via the spillover effects of FDI.

Conversely, domestic firms with low productivity, which are thus more distant from the world technological frontier, will perform worse owing to the entry of foreign firms, thus leading to the negative spillover effect. Our interpretation for this is straightforward. Because these low-productivity firms are too distant from the world frontier, the absorptive capacity is too limited for them to obtain the knowledge transfer or know-how spillovers from the foreign capital. Alternatively, the firms with lower productivity are more low-cost labor driven and less technology driven. They are therefore more likely to be crowded out by the multinationals or foreign enterprises with higher productivity, especially when the productivity gap becomes larger.

IV. Empirical strategy

1. Empirical model

To test our theoretical model, we start with a Cobb–Douglas function to conduct an empirical analysis as shown in Equation (17):

$$Y = AL^{\alpha}K^{\beta},\ 0 \leqslant a \leqslant 1,\ 0 \leqslant \beta \leqslant 1,\ a + \beta = 1, \tag{17}$$

where Y is the output, A is total factor productivity, L is labor, and K is capital. The spillover effect of FDI can increase the productivity, and the total factor productivity A is a function of FDI (e.g. Fu and Balasubramanyam, 2005; Wang et al., 2020b). We therefore have:

$$A = F(FDI). \tag{18}$$

According to the discussion on our theoretical proposition, the share of foreign capital determines the extent of the FDI spillover effect (e.g. Javorcik, 2004; Lu et al., 2017). Equation (18) can therefore be specified as in Equations (19) and (20):

$$A = e^{\delta X}\left(\frac{FDI}{DI}\right)^{\theta}, \tag{19}$$

$$DI = K - FDI, \tag{20}$$

where $\boldsymbol{X}$ is a vector capturing the firm characteristics that can potentially affect the total factor productivity. DI is domestic capital. θ is the coefficient of the awaiting to be tested and it varies according to different firms (i.e. the high-productivity and low-productivity firms). By dividing labor L both in the numerator and denominator, Equation (19) can be rewritten as follows:

$$A = e^{\delta X}\left(\frac{\frac{FDI}{L}}{\frac{DI}{L}}\right)^{\theta}. \tag{21}$$

Combining Equations (17) and (21), we obtain

$$Y = (e^{\delta X}\left(\frac{\frac{FDI}{L}}{\frac{DI}{L}}\right)^{\theta})L^{\alpha}K^{\beta},\ 0 \leqslant a \leqslant 1,\ 0 \leqslant \beta \leqslant 1,\ a + \beta = 1. \tag{22}$$

Taking log on both sides and rearranging the equation, we have:

$$\ln\frac{Y}{L} = \theta\left(\ln\frac{FDI}{L} - \ln\frac{DI}{L}\right) + \beta\ln\frac{K}{L} + \delta\boldsymbol{X},\ 0 \leqslant \beta \leqslant 1. \tag{23}$$

The productivity gap between foreign firms and domestic firms can therefore be proxied as the difference between foreign capital efficiency and the domestic capital efficiency (i.e. $\ln\frac{FDI}{L}-\ln\frac{DI}{L}$). Equation (22) is equivalent to Equation (24) as follows:

$$\ln y=\theta\left(\ln\frac{FDI}{DI}\right)+\beta\ln k+\delta \boldsymbol{X},\ 0\leqslant\beta\leqslant 1, \tag{24}$$

where y is output per capita and k is capital per capita. To corroborate the interplay productivity gap and the efficiency in the theoretical model is therefore essentially to test how the ratio of foreign capital over domestic capital affects the efficiency. Following previous studies (e.g. Aitken and Harrison, 1999; Hu and Jefferson, 2002; Anwar and Sun, 2014), we specify our empirical model in Equation (25):

$$\ln y_{it}=a_1+\alpha_2\ln fd_{it}+\alpha_3\ln hd_{it}+\beta \boldsymbol{X_{it}}+\varepsilon_{it}, \tag{25}$$

where y_{it} is the output level of firm i in year t. We distinguish between FDI from two origins – foreign origins and HMT origins – because the investments from foreign origins and HMT origins differ in productivity; fd_{it} is the ratio of foreign capital over the domestic capital in firm i in year t; hd_{it} is the ratio of HMT capital over the domestic capital in firm i year t. The control variables in vector $\boldsymbol{X}_{it}$ include I_{it}, the intermediate input in processing goods in firm i in time t; k_{it} is the capital per capita in firm i in year t; ex_{it} is the ratio of the value of export goods over total sales in firm i in year t; $size_{it}$ is the firm size in firm i in year t; soe_{it} shows whether the firm i in year t is a state-owned enterprise; age_{it} is the age of firm i in year t; ε_{it} is the error term.

2. Data

The data used in the empirical analysis come from the annual survey of Chinese industrial enterprises conducted by the National Bureau of Statistics of China in the period 2005–2013, which includes comprehensive firm-level information in all industrial sectors. After clearing the data based on the approach of Brandt et al. (2012), we obtained 2,944,305 observations in 9 years. Descriptive statistics are shown in Table 1.

The dataset further enables us to separate most of the firms into six industrial sectors, namely mining, light industry, chemicals, heavy industry, high-tech manufacturing and other manufacturing industry, according to the classification of two-digit Standard Industrial Classification codes. As presented in Table 2, the average productivity of firms in the mining industry, light industry and other manufacturing industry is lower than the average of productivity level of the whole industry while the average productivity level of firms in heavy industry, chemical industry and high-tech industry is higher than that of the whole industry.

Table 1. Descriptive statistics

Variable	Definition	Mean	Standard deviation	Observations
ln*y*	Output per capita (thousand RMB/persons)	4.883	2.351	2,944,305
ln*k*	Registered capital per laborer (thousand RMB/persons)	3.130	2.977	2,944,305
ln*l*	Intermediate input (Thousand RMB)	2.828	4.512	2,944,305
ln*fd*	Foreign capital over domestic capital (%)	–0.052	0.221	2,944,305
ln*hd*	HMT capital over domestic capital (%)	–0.066	0.224	2,944,305
soe	State owned enterprise =1 (dummy)	0.121	0.145	2,944,305
ex	Export over total sales (%)	0.153	0.381	2,944,305
size	Number of employees (in log)	4.338	1.771	2,944,305
age	Firm age (years)	10.32	10.39	2,944,305

Source: Annual survey of Chinese industrial enterprises conducted by the National Bureau of Statistics of China.

Table 2. Summary statistics of firms in different industry sectors

Industry sector	ln*y*	ln*k*	ln*fd*	ln*hd*	Observations
Mining industry (–)	4.792 (2.449)	2.774 (2.015)	–0.105 (0.124)	–0.134 (0.106)	136,602
Light industry (–)	4.795 (2.284)	2.731 (1.865)	–0.053 (0.222)	–0.019 (0.234)	897,156
Others (–)	4.811 (2.440)	3.333 (2.358)	–0.062 (0.223)	–0.061 (0.238)	111,492
Entire manufacturing industry	4.883 (2.351)	3.130 (2.977)	–0.052 (0.221)	–0.066 (0.224)	2,944,305
Heavy industry (+)	4.936 (2.391)	2.941 (1.963)	–0.043 (0.221)	–0.045 (0.198)	764,217
High-tech industry (+)	4.953 (2.370)	3.293 (2.042)	–0.031 (0.294)	–0.037 (0.273)	81,288
Chemical industry (+)	5.118 (2.355)	3.148 (1.999)	–0.016 (0.225)	–0.068 (0.230)	472,068

Notes: Some companies cannot be classified into subgroups due to missing industry code information. –, low-productivity sector; +, high-productivity sector. See Table 1 for the definitions of all variables.

We therefore classify them into low-productivity sectors and high-productivity sectors. Regarding foreign capital, the chemical industry sector has the biggest proportion of foreign capital and the high-tech industry sector has the second largest proportion while the portion flowing into the mining sector is the lowest. As for HMT capital, the light industry sector receives the largest portion of the HMT capital and high-tech industry sector, heavy industry sector, other industry sector, chemical industry sector, and mining sector range from the second highest to the lowest.

V. Results

1. Baseline estimates

We first investigate the effect of the productivity gap between domestic firms and foreign firms, and that between domestic firms and HMT firms, on output level. Table 3 presents the results of baseline estimation. We employ different econometric models, including pooled OLS (ordinary least squares) regression, random effect, fixed effect, and generalized method of moments (GMM) models to cope with the potential endogeneity caused by the presence of reverse causality and heterogeneity. In Table 3, with baseline estimates for the general case (full sample), columns (1)–(2), (3)–(4), (5)–(6), and (7)–(8) report the results of the pooled OLS, random effect (RE), fixed effect (FE) and system GMM estimates, respectively. Estimates in each model are pairwise to compare the results before and after state ownership of firms is taken into account. As expected, the output is positively associated with their capital per capita and the intermediate inputs.

In columns (1), (3), (5), and (7), the coefficient of ln*fd* is positive and statistically significant at 1 percent, which means that the productivity gap, measured by the ratio of foreign capital over domestic capital at firm level, has a positive spillover effect on output. More specifically, 1 percentage increase in foreign capital contributes to a 0.074 percent increase in firms' productivity based on pooled OLS estimates. This positive effect becomes more economically significant in RE and FE estimates with a 1 percent increase in foreign capital accounting for 0.119 and 0.120 percent growth of the firms' productivity, respectively. The positive spillover effect of FDI is more pronounced in GMM estimates, where the endogeneity issue is addressed well. The negative and statistically significant coefficient of the first-order autoregression (AR) test and statistically insignificant coefficient of the second-order AR test indicate that the moments are well specified. The results of the Sargan test indicate the instruments are valid. We observe that a one-unit increase in foreign capital enhances the firms' productivity by 0.393 percent in the GMM model.

Similarly, the coefficient of ln*hd* is positive and statistically significant in most models. Yet, compared with the capital with foreign origins, the capital from HMT origins also has a positive effect on the firms' productivity but is less economically significant. For example, 1 percent increase in foreign capital raises the productivity by 0.018 and 0.033 percent, respectively, in the OLS and RE models, which is economically negligible. In GMM estimates, the effect is relatively more salient, accounting for a 0.141 percent increase in the firms' productivity. This positive effect can be interpreted as the inner-sector or horizontal effect (Lu et al., 2017) and is the spillover effect of FDI from other companies in the same sector and the agglomeration effect (Konrad and Kevenock, 2009).

Table 3. Estimates for the effect of FDI on productivity: Full sample

Variable	(1) Pooled OLS	(2) Pooled OLS	(3) Random	(4) Random	(5) Fixed	(6) Fixed	(7) GMM	(8) GMM
ln*fd*	0.074*** (0.016)	0.085*** (0.025)	0.119*** (0.031)	0.126*** (0.023)	0.120*** (0.035)	0.124*** (0.043)	0.393*** (0.097)	0.401*** (0.110)
ln*hd*	0.018 (0.013)	0.013* (0.007)	0.033*** (0.012)	0.055*** (0.014)	0.043 (0.027)	0.044* (0.026)	0.141** (0.056)	0.153** (0.078)
ln*fd* × *soe*		0.060*** (0.011)		0.082** (0.040)		0.063*** (0.021)		0.149* (0.038)
ln*hd* × *soe*		0.015*** (0.005)		0.052*** (0.013)		0.020 (0.014)		0.042** (0.021)
soe		–0.011*** (0.004)		–0.012*** (0.004)		–0.086*** (0.005)		–0.138*** (0.017)
exp	–0.354*** (0.002)	–0.356*** (0.002)	–0.241*** (0.002)	–0.240*** (0.002)	–0.171*** (0.002)	–0.171*** (0.003)	–0.257*** (0.004)	–0.256*** (0.004)
ln*k*	0.311*** (0.001)	0.312*** (0.001)	0.365*** (0.001)	0.366*** (0.001)	0.371*** (0.001)	0.371*** (0.001)	0.698*** (0.001)	0.703*** (0.002)
ln*l*	0.425*** (0.001)	0.425*** (0.001)	0.261*** (0.001)	0.262*** (0.001)	0.189*** (0.001)	0.191*** (0.001)	0.337*** (0.003)	0.341*** (0.004)
size	–0.023*** (0.001)	–0.022*** (0.001)	–0.714*** (0.001)	–0.718*** (0.001)	0.147*** (0.001)	0.148*** (0.001)	0.761*** (0.001)	0.753*** (0.002)
age	–0.007*** (0.001)	–0.006*** (0.001)	–0.005*** (0.001)	–0.007*** (0.001)	–0.017*** (0.001)	–0.019*** (0.001)	0.016*** (0.004)	0.016*** (0.005)
lny_{t-1}							0.121*** (0.017)	0.116*** (0.024)
Year-fixed	No	No	No	No	Yes	Yes	Yes	Yes
Firm-fixed	No	No	No	No	No	No	No	No
Adjusted R^2	0.8044	0.8045	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
R^2 within	N.A.	N.A.	0.8776	0.8776	0.8824	0.8825	N.A.	N.A.
R^2 between	N.A.	N.A.	0.7449	0.7450	0.5969	0.5971	N.A.	N.A.
R^2 overall	N.A.	N.A.	0.7982	0.7982	0.6572	0.6572	N.A.	N.A.
AR(1) *p*-value	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.033	0.027
AR(2) *p*-value	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.097	0.102
Sargan *p*-value	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.119	0.083
Observations	2,944,305	2,944,305	2,944,305	2,944,305	2,944,305	2,944,305	1,962,870	1,962,870

Notes: ***, **, and * represent significance at the 1, 5, and 10 percent levels, respectively. Robust standard errors are in parentheses. See Table 1 for the definitions of all variables. AR(1), first-order autocorrelation; AR(2), second-order autocorrelation; GMM, generalized method of moments; OLS, ordinary least squares.

In columns (2), (4), (6), and (8), we consider the nexus of state ownership, the FDI spillover effect, and firms' productivity. The coefficient of ln*fd* and ln*hd* remains positive while the coefficient of *soe* is negative and both are statistically significant in all models. The latter indicates that the state-owned enterprises (SOEs) are less productive than their counterparts. Intuitively, in the context of China, the SOEs are more oriented to the planned economy than market oriented. Productivity is therefore not an important determinant of their survival in the market. However, the coefficient of the interaction term between *soe* and ln*fd*, ln*fd* × *soe*, is positive and statistically significant, which shows that the entry of foreign capital in the SOEs stimulates their efficiency. This also likewise applies to the case of HMT capital, where the coefficient of ln*hd* × *soe* is positive and statistically significant. Our understanding is straightforward: the entry of foreign and HMT capital into the SOEs signals the reform of Chinese SOEs and productivity is increasingly a concern in this process.

As for the control variables, the coefficients overall maintain expected signs in different estimates. Capital per capita and intermediate input are positively related to productivity whereas export ratio, firm size, and age are negatively associated with productivity. These results reveal that the lower labor cost has made China a major exporter in past decades. Both relatively larger and more aged firms also experience a decrease in productivity because younger firms appear to benefit from a "latecomer's advantage"[3] and high-productivity firms prefer the quality instead of quantity of laborers. In the dynamic panel analysis, the coefficient of productivity in the previous year is positive and statistically positive.

2. High-productivity firms vis-à-vis low-productivity firms

The above analysis outlines a general case in terms of the spillover effect of foreign and HMT capital. To correspond more closely with what is conveyed in our theoretical model, we investigate how the spillover effect of FDI differs for high-productivity firms vis--vis low-productivity firms in this section. According to the classification in Table 2, we divide the firms into six groups, with three each in the high-productivity firms and low-productivity firms.

Table 4 presents the estimated outcomes for the high-productivity firms (industries). Columns (1)–(3) report the results for chemical industry in RE, FE, and GMM, respectively. The share of foreign capital has a positive effect on

[3]"Latecomer's advantage" refers to technological innovation and productivity enhancement that can be achieved by imitation, import, and / or integration of existing technologies and industries, all of which imply much lower costs.

Table 4. Estimates for the effect of FDI on productivity: High-productivity firms

	Chemical industry			Heavy industry			High-tech industry		
	(1) Random	(2) Fixed	(3) GMM	(4) Random	(5) Fixed	(6) GMM	(7) Random	(8) Fixed	(9) GMM
ln*fd*	0.218* (0.114)	0.185*** (0.065)	0.554* (0.287)	0.159* (0.079)	0.332*** (0.082)	0.549** (0.198)	0.139** (0.059)	0.221* (0.133)	0.336*** (0.121)
ln*hd*	0.087** (0.039)	0.098* (0.056)	0.123 (0.109)	0.113*** (0.032)	0.161* (0.088)	0.086 (0.123)	0.043 (0.051)	0.198** (0.097)	0.183 (0.604)
ln*fd* × *soe*	0.176*** (0.062)	0.131*** (0.047)	0.380* (0.222)	0.083 (0.075)	0.068 (0.083)	0.249 (0.181)	0.232** (0.113)	0.126* (0.071)	0.218 (0.278)
ln*hd* × *soe*	0.221* (0.117)	0.158** (0.072)	0.438* (0.246)	0.112* (0.070)	0.052 (0.080)	0.126 (0.094)	0.209** (0.081)	0.072 (0.092)	0.068 (0.071)
soe	–0.282* (0.153)	0.182 (0.164)	–0.387 (0.296)	0.229 (0.205)	–0.034 (0.233)	–0.465** (0.230)	0.596** (0.303)	0.391 (0.312)	0.499 (0.482)
ln*k*	0.433*** (0.033)	0.561*** (0.091)	0.495*** (0.106)	0.490*** (0.023)	0.548*** (0.057)	0.164 (0.138)	0.374*** (0.050)	0.364*** (0.145)	0.308*** (0.167)
ln*l*	0.269*** (0.039)	0.187*** (0.048)	0.242*** (0.039)	0.129** (0.024)	0.148* (0.026)	0.088** (0.025)	0.159*** (0.038)	0.266 (0.405)	0.264 (0.189)
exp	–0.255** (0.103)	–0.194 (0.131)	–0.338*** (0.073)	–0.312*** (0.074)	–0.311*** (0.089)	–0.292*** (0.060)	–0.425*** (0.086)	–0.395*** (0.090)	–0.475*** (0.169)
size	0.057 (0.042)	–0.239** (0.095)	–0.452*** (0.131)	0.063 (0.050)	–0.177*** (0.056)	–0.663*** (0.153)	–0.273*** (0.055)	–0.617*** (0.146)	–0.557*** (0.219)
age	–0.239*** (0.062)	–0.263*** (0.073)	–0.230** (0.041)	–0.133*** (0.029)	–0.097** (0.042)	0.127*** (0.032)	0.002 (0.008)	0.132** (0.062)	0.182** (0.076)
lny_{t-1}			0.060** (0.027)			0.082 (0.085)			0.025 (0.042)
Year-fixed	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Firm-fixed	No	No	No	No	No	No	No	No	No
R^2 within	0.2446	0.2971	N.A.	0.2108	0.2715	N.A.	0.6276	0.7297	N.A.
R^2 between	0.3054	0.3451	N.A.	0.4625	0.2450	N.A.	0.5957	0.5575	N.A.
R^2 overall	0.3015	0.3375	N.A.	0.4421	0.2227	N.A.	0.5974	0.5777	N.A.
AR (1) *p*-value	N.A.	N.A.	0.051	N.A.	N.A.	0.017	N.A.	N.A.	0.009
AR (2) *p*-value	N.A.	N.A.	0.186	N.A.	N.A.	0.239	N.A.	N.A.	0.473
Sargan *p*-value	N.A.	N.A.	0.095	N.A.	N.A.	0.416	N.A.	N.A.	0.163
Observations	472,068	472,068	314,712	764,217	764,217	509,478	81,288	81,288	54,192

Notes: ***, **, and * represent significance at the 1, 5, and 10 percent levels, respectively. Robust standard errors are in parentheses. See Table 1 for the definitions of all variables. AR(1), first-order autocorrelation; AR(2), second-order autocorrelation; GMM, generalized method of moments.

productivity at statistical significance levels of 10 percent in the RE model, 1 percent in the FE model, and 1 percent in the GMM, which is consistent with the baseline results. Similarly, we also found evidence that the share of HMT capital displays a positive association with productivity, although in the GMM model the results were statistically insignificant. Notwithstanding that the state ownership is only statistically significant in the RE model, its interaction terms with *fd* and *hd* are both positive and statistically significant, which supports our previous interpretation based on the full sample estimates. In columns (4)–(6) and (7)–(9), pertaining to firms in heavy industry and high-tech industry, respectively, we find that the positive effect of foreign and HMT capital still exists but we do not find much evidence that the partnership with foreign and HMT capital operates more efficiently. One possible explanation is that the independent research and development capabilities of the SOEs in both heavy and high-tech industry have been upgraded due to the vigorous and continuous support from the government. Hence, on the one hand, the entry of foreign capital is limited to some extent. On the other hand, foreign capital plays a less important role in breaking through the advanced level of innovation ability of the SOEs.

As a comparison, Table 5 presents the estimated outcomes for the low-productivity firms (industries). Columns (1)–(3), (4)–(6), and (7)–(9) report the results for the mining industry, light industry, and other secondary industries, respectively, with RE, FE, and GMM. Unlike the results of high-productivity firms, the coefficients of ln*fd* and ln*hd*, the foreign and HMT capital share are negative and mostly statistically significant. This suggests that the entry of foreign and HMT capital has a negative effect on the firms' productivity in general, which is in line with Girma (2005), who argues that the spillover effect of FDI can be negligible and even negative depending on the threshold level of the domestic firms' absorptive capacity. As a bad sign, the negative spillover effect may refer to an overture of the crowding-out effect. For instance, Aitken and Harrison (1999) and Lu et al. (2017) argue that domestic firms may lose market share due to the entry of foreign capital with higher productivity.

Nevertheless, this seems not to apply to state-owned enterprises as indicated by the positive and statistically significant coefficients of the interaction terms ln*fd* × soe and ln*fd* × *soe*. The values of the coefficients are larger than those of the original terms and therefore overturn the negative effect. That is, the SOEs greatly enhance their productivity owing to coloration with the foreign and HMT capital. Here, we share the same interpretation with Fu (2008) who argues that the SOEs can still maintain a high level of absorptive capacity due to domestic protection even when the productivity gap is large.

Table 5. Estimates for the effect of FDI on productivity: Low-productivity firms

	Mining			Light industry			Others		
	(1) Random	(2) Fixed	(3) GMM	(4) Random	(5) Fixed	(6) GMM	(7) Random	(8) Fixed	(9) GMM
ln*fd*	–0.118 (0.186)	–0.093** (0.036)	–0.162*** (0.058)	–0.047 (0.029)	–0.083*** (0.026)	–0.102*** (0.031)	0.043 (0.073)	–0.055*** (0.018)	–0.299 (0.221)
ln*hd*	–0.010 (0.048)	–0.064* (0.037)	–0.097** (0.049)	–0.089 (0.066)	–0.026** (0.013)	0.087 (0.073)	–0.037** (0.019)	0.096 (0.130)	–0.122* (0.712)
ln*fd* × *soe*	0.409* (0.231)	0.311 (0.192)	0.162*** (0.058)	–0.009 (0.173)	0.314** (0.153)	0.421*** (0.073)	0.031 (0.063)	0.067 (0.068)	0.312* (0.187)
ln*hd* × *soe*	0.386*** (0.128)	0.256* (0.149)	0.132** (0.064)	–0.038 (0.159)	0.118 (0.403)	0.094 (0.107)	0.099 (0.065)	0.056 (0.062)	0.191 (0.168)
soe	–0.408 (0.293)	0.328 (0.426)	–0.334 (0.276)	–0.259 (0.343)	–0.656 (0.476)	–0.165* (0.098)	–0.027* (0.016)	0.022 (0.061)	–0.038 (0.067)
ln*k*	0.182* (0.107)	0.148** (0.075)	0.091* (0.048)	0.539*** (0.021)	0.501*** (0.048)	0.280** (0.142)	0.592*** (0.041)	0.659*** (0.080)	0.840** (0.413)
ln*l*	0.087 (0.093)	0.063 (0.241)	0.071* (0.041)	0.052*** (0.020)	0.024 (0.021)	0.031** (0.014)	0.110** (0.051)	0.077 (0.053)	0.068 (0.076)
exp	–0.286** (0.107)	–0.258* (0.135)	–0.145 (0.109)	–0.292*** (0.048)	–0.283*** (0.057)	–0.153 (0.169)	0.084 (0.066)	–0.185 (0.326)	–0.317 (0.219)
size	–0.683*** (0.205)	–0.593* (0.335)	0.753** (0.382)	0.217*** (0.026)	0.083 (0.057)	–0.321 (0.209)	0.397*** (0.068)	0.557*** (0.082)	–0.631*** (0.117)
age	0.015 (0.028)	–0.136 (0.232)	0.045* (0.026)	–0.002 (0.004)	–0.013 (0.009)	0.105 (0.092)	–0.069 (0.091)	0.161* (0.084)	0.251 (0.302)
$\ln y_{t-1}$			0.074*** (0.023)			0.081* (0.047)			0.128* (0.074)
Year-fixed	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Firm-fixed	No	No	No	No	No	No	No	No	No
R^2 within	0.5206	0.8454	N.A.	0.3827	0.4537	N.A.	0.7898	0.8618	N.A.
R^2 between	0.6095	0.5099	N.A.	0.4304	0.5178	N.A.	0.6650	0.1454	N.A.
R^2 overall	0.5764	0.5566	N.A.	0.4094	0.4931	N.A.	0.7077	0.1226	N.A.
AR(1) *p*-value	N.A.	N.A.	0.035	N.A.	N.A.	0.043	N.A.	N.A.	0.026
AR(2) *p*-value	N.A.	N.A.	0.387	N.A.	N.A.	0.562	N.A.	N.A.	0.331
Sargan *p*-value	N.A.	N.A.	0.182	N.A.	N.A.	0.091	N.A.	N.A.	0.143
Observations	136,602	136,602	91,068	897,156	897,156	598,104	111,492	111,492	74,328

Notes: ***, **, and * represent significance at the 1, 5, and 10 percent levels, respectively. Robust standard errors are in parentheses. See Table 1 for the definitions of all variables. AR(1), first-order autocorrelation; AR(2), second-order autocorrelation; GMM, generalized method of moments.

Overall, along with the results from high-productivity firms, these findings support the propositions in our theory model. The entry of foreign and HMT capital has a positive spillover effect on the high-productivity firms, in which case there is less of a productivity gap, but has a negative spillover effect on the low-productivity firms, in which case there is more of a productivity gap. Additionally, we find strong evidence that the productivity increases as the entry of foreign and HMT capital in the state-owned enterprises regardless of the low-productivity or high-productivity firms. This also suggests, at least partially, that the reform of Chinese state-owned enterprises with respective to the involvement of foreign and capital is successful.

VI. Conclusions

The debate on the relationship between FDI spillovers and the productivity gap in the literature is ongoing. A clear theoretical model is required to identify the circumstances under which FDI has positive spillovers on productivity. In this paper, we establish a two-stage game theoretical model to provide a better understanding of the spillovers of FDI by showing that productivity gap between foreign firms and domestic firms matters. According to our theoretical model, given the optimal joint-venture policy made by foreign firms, the impact of the spillover effect of inward FDI is contingent upon the productivity gap between domestic capital and foreign capital. Such a spillover effect of FDI inward varies negatively with the productivity gap between low-productivity domestic firms and foreign firms but displays a positive effect on high-productivity domestic firms. This result suggests that, once the productivity gap is enlarged, the entry of foreign firms promotes the efficiency of high-productivity firms whereas it reduces the efficiency of low-productivity firms.

Using a comprehensive annual survey dataset pertaining to over 327,000 Chinese industrial firms from 2005 to 2011, we found that the entry of foreign and HMT capital had a positive spillover effect on the high-productivity firms, in which case there was less of a productivity gap, but it had a negative spillover effect on the low-productivity firms, in which case there is more of a productivity gap. We also found strong evidence that productivity increases with the entry of foreign and HMT capital in the SOEs regardless of the productivity of these firms. This also suggests, at least partially, that the reform of Chinese SOEs with respect to the involvement of foreign and HMT capital is successful. These findings are robust to different econometric models and well aligned with our theoretical model.

Admittedly, there are several limitations of our study that could lead to some thoughts about future research. First, given the rapid growth of China's inward FDI, we only focused on the case of China and we used a sample of Chinese firms. Future research may consider data from enterprises in other emerging economies to expand our theoretical model in a broader sense or to compare the differences. Second, our empirical strategy used a survey of Chinese industrial enterprises, which rarely record the entry mode of the inward FDI, leaving questions such as whether the entry mode of inward FDI can shape the productivity gap between foreign firms and domestic firms. Third, the productivity gap can be designed and calculated more accurately with refined data that may appear in the future to compare the productivity of the foreign enterprises before they invest in Chinese firms. It therefore requires a much more comprehensive dataset, containing more information about the foreign enterprises, which have different origins. Despite the limitations, this research is one of the first attempts to explain theoretically and test empirically why there can be positive or negative spillover effects of FDI on productivity.

Several policy considerations can be obtained from our findings. As one of the largest FDI recipients in the world, China has passed the stage of seeking a large quantity of FDI. It is therefore of crucial importance to chase high-quality FDI (i.e. innovation and technology oriented) and foreign cooperation. Meanwhile, selecting compatible foreign or HMT partners is a prerequisite for more efficient and market-favorable cooperation, especially for low-productivity firms. Conversely, this should also apply to foreign firms that may be keen to invest in China and expand their Chinese market. In this transition, state-owned enterprises are expected to serve as short-term lubricants to mediate conflicts and inefficiency whenever and wherever necessary in the market.

References

Aitken, B. J. and A. E. Harrison, 1999, "Do domestic firms benefit from direct foreign investment? Evidence from Venezuela," *American Economic Review*, Vol. 89, No. 3, pp. 605–18.

Anwar, S. and S. Sun, 2014, "Heterogeneity and curvilinearity of FDI-related productivity spillovers in China's manufacturing sector," *Economic modelling*, Vol. 41, pp. 23–32.

Brandt, L., J. V. Biesebroeck and Y. Zhang, 2012, "Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing," *Journal of Development Economics*, Vol. 97, No. 2, pp. 339–51

Baldwin, R., H. Braconie and R. Forslid, 2005, "Multinationals, endogenous growth and technological spillovers: Theory and evidence," *Review of International Economics*, Vol. 13, No. 5, pp. 945–63.

Blomstrom, M. and A. Kokko, 1998, "Multinational corporations and spillovers," *Journal of Economic Surveys*, Vol. 2, pp. 247–77.

Buckley, P., J. Clegg and C. Wang, 2010, "Is the relationship between inward FDI and spillover effects linear? An empirical examination of the case of China," *Journal of International Business Studies*, Vol. 38, pp. 447–59.

Chen, C. and Y. Wu, 2017, "Impact of foreign direct investment and export on urbanization: Evidence from China," *China & World Economy*, Vol. 75, No. 1, pp. 71–89.

Chen, C., 2015, "Do inland provinces benefit from coastal foreign direct investment in China?" *China & World Economy*, Vol. 23, No. 3, pp. 22–41

Caves, R. E., 1974, "Multinational firms, competition, and productivity in host country markets," *Economica*, Vol. 41, No. 162, pp. 176–93.

Chen, T., A. Kokko and P. Tingvall, 2011, "FDI and spillovers in China: Non-linearity and absorptive capacity," *Journal of Chinese Economic and Business Studies*, Vol. 9, No. 1, pp. 1–22.

Farole, T. and D. Winkler, 2012, "Foreign firm characteristics, absorptive capacity and the institutional framework – The role of mediating factors for FDI spillovers in low- and middle-income countries," *Policy Research Working Paper*, The World Bank.

Flores, R. G., M. P. Fontoura and R. G. Santos, 2007, "Foreign direct investment and spillovers: Additional lessons from a country study," *European Journal of Development Research*, Vol. 19, No. 3, pp. 372–90.

Fu, X. and V. N. Balasubramanyam, 2005, "Exports, foreign direct investment and employment: The case of China," *The World Economy*, Vol. 28, No. 4, pp. 607–25.

Fu, X., 2008, "Foreign direct investment, absorptive capacity and regional innovation capabilities: Evidence from China," *Oxford Development Studies*, Vol. 36, No. 1, pp. 89–110.

Girma, S., 2005, "Absorptive capacity and productivity spillover from FDI: A threshold regression analysis," *Oxford Bulletin of Economics and Statistics*, Vol. 67, No. 3, pp. 281–306.

Globerman, S., 1979, "Foreign direct Investment and spillover efficiency benefits in Canadian manufacturing industries," *Canadian Journal of Economics*, Vol. 12, No. 1, pp. 51–74.

Görg, H. and D. Greenaway, 2004, "Much ado about nothing? Do domestic firms really benefit from foreign direct investment?" *World Bank Research Observer*, Vol. 19, No. 2, pp. 171–97.

Hale, G. and C. Long, 2006, "What determines technological spillovers of foreign direct investment: Evidence from China," *Center Discussion Paper* No. 934, Economic Growth Center, Yale University.

Hu, A. G. Z. and G. H. Jefferson, 2002, "FDI impact and spillover: Evidence from China's electronic and textile industries," *The World Economy*, Vol. 25, No. 8, pp. 1063–76.

Javorcik, B. S., 2004, "Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages," *American Economic Review*, Vol. 94, No. 3, pp. 605–27.

Kokko, A., 1996, "Productivity spillovers from competition between local firms and foreign affiliates," *Journal of International Development*, Vol. 8, No. 4, pp. 517–30.

Kokko, A., R. Tansini and M. Zajan, 1996, "Local technological capability and productivity spillovers from FDI in the Uruguayan manufacturing sector," *Journal of Development Studies*, Vol. 32, No. 4, pp. 602–11

Konrad, K. A. and D. Kovenock, 2009, "Competition for FDI with vintage investment and agglomeration advantages," *Journal of International Economics*, Vol. 79, No. 2, pp. 230–37.

Lee, C. C. and C. P. Chang, 2009, "FDI, financial development, and economic growth: International evidence," *Journal of Applied Economics*, Vol. 12, No. 2, pp. 249–71.

Lin, F., C. Zhang and L. Wang, 2013, "Vertical spillover effects of multinationals on Chinese domestic firms via supplier–customer relationships," *China & World Economy*, Vol. 21, No. 6, pp. 37–57.

Liu, X., P. Siler, C. Wang and Y. Wei, 2000, "Productivity spillovers from foreign direct investment: Evidence from UK industry level panel data," *Journal of International Business Studies*, Vol. 31, pp. 407–25.

Liu, Z., 2008, "Foreign direct investment and technology spillovers: Theory and evidence," *Journal of Development Economics*, Vol .85, No. 1, pp. 176–93.

Lu, Y., Z. Tao and L. Zhu, 2017, "Identifying FDI spillovers," *Journal of International Economics*, Vol. 107, pp. 75–90.

Rodrik, D., 1999, "The new global economy and developing countries: Making openness work," *Overseas Development Council Policy Essay* No. 24, Johns Hopkins University Press, Washington, DC.

Sjoholm, F., 1999, "Productivity growth in Indonesia: The role of regional characteristics and direct foreign investment," *Economic Development and Cultural Change*, Vol. 47, No. 3, pp. 559–84.

Wang, H., J. Fidrmuc and Q. Luo, 2020a, "Spatial analysis of inward FDI and rural–urban wage inequality: Evidence from China," *GLO Discussion Paper* No. 522, Global Labor Organization (GLO), Essen.

Wang, H., J. Fidrmuc and Y. Tian, 2020b, "Growing against the background of colonization? Chinese labor market and FDI in a historical perspective," *International Review of Economics & Finance*, Vol. 69, pp. 237–56.

Whalley, J. and X. Xin, 2010, "China's FDI and non-FDI economies and the sustainability of future Chinese growth," *China Economic Review*, Vol. 21, No. 1, pp. 123–35.

Xu, X. and Y. Sheng, 2012, "Are FDI spillovers regional? Firm-level evidence from China," *Journal of Asian Economics*, Vol. 23, pp. 244–58.

Yao, S., 2006, "On economic growth, FDI and exports in China," *Applied Economics*, Vol. 38, No. 3, pp, 339–51.

Zhang, K. H., 2001, "How does foreign direct investment affect economic growth in China?" *Economics of Transition*, Vol. 9, No. 3, pp. 679–93.

(Edited by Xiaoming Feng)