Disentangling the Puzzle of FDI Horizontal Spillover Effects: Theory and Evidence

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Abstract
It has been observed by numerous empirical studies that for most of the cases horizontal spillover effects are either negative or insignificant, whereas positive productivity spillovers from FDI are more likely to take place through vertical linkages. This paper is an attempt to present one reasonable explanation for these two opposite impacts from a new point of view – the existence of learning costs. Besides this, we take one step further getting to the bottom of the true effects of horizontal linkages on productivity development of local firms by distinguishing between the level and rate effects generated by horizontal spillovers. Starting from a theoretical framework, we find that horizontal spillovers may use learning investment as a vehicle to exert negative effect, meanwhile vertical spillovers generate positive impact on domestic firms’ productivity. What’s more, except for the detrimental productivity level effect, a hidden positive productivity growth rate effect is also discovered through horizontal linkages, implying that the negative horizontal spillover effect is only a temporary phenomenon. To further prove the plausibility of our analysis, an empirical estimation with China’s industry-level penal data over a period 2003-2012 is included in this paper. Estimation results give suggestive evidence for the vital insights obtained in theoretical study.

Keyword
n horizontal FDI、vertical FDI、learning cost、productivity growth
1. Introduction

According to a report from UNCTAD, the share and volume of foreign direct investment (FDI) inflows to developing countries has been increasing for the last three decades. When taking a close look at FDI inflows to less-developed countries, we will readily find that they are mainly concentrated in East Asia and Latin America. Interestingly, the FDI receiving booms of many countries in these two areas coincided with their miraculous achievement in economic development and prosperity, which also occurred in the past three decades. Such coincidence makes people naturally associate economic growth and productivity gain with inward FDI. Furthermore, impressive claims such as World Bank (1993) saying that “[FDI] brings with it considerable benefits: technology transfer, management know-how, and export marketing access. Many developing countries will need to be more effective in attracting FDI flows if they are to close the technology gap with high-income countries, upgrade managerial skills, and develop their export markets”, are undoubtedly a strong impetus to policy makers in less developed economies to place attracting FDI high on their agenda.

Holding the belief that multinational enterprises (MNEs) confer “technology spillovers” to domestic firms, nowadays many developing countries endeavor to attract FDI by offering generous investment packages. However, the question is: Is inward FDI really the magical concoction that can enhance productivity of domestic firms in recipient country.

In order to obtain more accurate analysis about the influence of MNEs on productivity gain of domestic firms, recent work on this issue specifies FDI spillover effects into horizontal spillovers (effects that the presence of MNEs has on domestic firms in the same sector), and vertical

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1 One of the most iconic examples is China. Since 1980s (right after its economic reform in 1978), Chinese per capita income has increased 8-fold with an average growth rate of 9%. Also at the same time, from an almost isolated economy, China has surpassed the US as the world’s largest recipient of FDI for the first time since 2003 (UNCTAD, 2012).

2 Different kinds of special incentives are offered to foreign investors, such as tax holidays, import duty exemptions and subsidies for infrastructure. For example, foreign invested manufacturing companies operating in China for at least ten years are granted a tax exemption period from the date of entering the profit zone.
spillovers (potential influence from multinational firms on their domestic suppliers or consumers through vertical input-output linkages) 3. By doing so, several recent studies suggest that inter-industry spillovers are much more prevalent than intra-industry spillovers, since in most cases, positive spillovers through vertical linkages are found while the horizontal spillovers are either negative or statistically insignificant.

Empirical studies of different countries keep providing new evidence to support this finding. However, even though empirical studies on FDI’s productivity enhancing effects by identifying horizontal and vertical spillovers are legion, there still remains a puzzle: Why do intra-industry spillovers always generate unfavorable effect rather than behaving the same way as inter-industry spillovers do. So far, little effort has been made to give a good explanation for such phenomenon.

Therefore, we aim to contribute to the existing literature by shedding light on two issues: Why does the undesirable effect exists in horizontal linkages? And rest on the first question, this paper takes one step further by addressing another important related issue which is neglected by most of the existing studies: Will such kind of negative effect last forever, or is it just a temporary phenomenon.

In this paper, a theoretical framework utilizing the concept of learning cost is constructed to capture the abovementioned scenario. According to the properties of horizontal and vertical spillovers along with some anecdotal evidence, we conjecture that one possible difference between intra-industry spillovers and inter-industry spillovers could lie in learning cost. Foreign invested firms compete with their local rivals operating in the same sector. In order to grab market share and maintain their competitive advantage, multinationals have an incentive to prevent technology leakage from taking place. As a result, if indigenous firms want to obtain sophisticated technology from MNEs conducting production activity in the same sector, they need to make great efforts. Searching for information, reversed engineering, etc. make learning costly and time-

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3 Horizontal and vertical spillovers can also be called as intra-industry spillovers and inter-industry spillovers respectively.
consuming. How much resources should be devoted to learning is, therefore, essentially an investment decision. On the contrary, multinationals do not have strong incentive to prevent technology diffusion to their upstream suppliers, since they could benefit from the improved performance of their local intermediate input suppliers. Sometimes foreign invested firms even voluntarily help local suppliers to promote the production efficiency\(^4\). Therefore, we have a good reason to believe that the learning process in vertical linkages is not that costly or even free.

In light of the conjecture that local firms incur learning costs in order to learn from MNEs in the same sector, it is logical to consider that horizontal spillovers may temporarily have a negative effect on productivity level since indigenous firms need to sacrifice some production resources as the investment to get new technology; but a positive influence in the future, because such efforts for technology acquirement will help domestic firms with their future productivity capacity. The emanation of beneficial effects essentially relies on whether horizontal spillovers can positively affect productivity growth rate. When productivity growth rate of local firms is increasing along with the expansion of MNEs, then the productivity grows at a high speed. Therefore at some point of time in the future, local firms will recover from the initial productivity loss and thereafter the net effect of horizontal spillovers is positive and keeps growing overtime. In other words, the negative productivity level effect of horizontal spillovers is a temporary phenomenon\(^5\).

On the purpose of attaining a more complete story, this paper also contains empirical study with China’s industry-level penal data over a period 2003-2012 in line with the basic logic presented in theoretical model. Empirical estimation results give evidence to the plausibility of

\(^4\) As I mentioned earlier, vertical spillovers actually contain backward as well as forward spillovers. Backward spillovers of FDI refer to the spillover effects generated by foreign affiliates to their local suppliers through supply chains. Forward spillovers occur when domestic firms gain access to intermediate inputs that are less costly or with higher quality produced by MNEs in upstream industries. Many empirical researches show that compared with backward spillovers, even though the estimated coefficients on forward spillovers are positive, they are always statistically insignificant, implying that forward linkages can only generate very weak or even no cheering productivity enhancing impacts on indigenous firms (Harris, Robinson 2002). Therefore, in this paper, we only refer to backward spillovers as vertical spillovers.

\(^5\) Liu (2008) also uses growth rate to distinguish the short-run and long-run effects from MNEs on domestic firms.
our theoretical analysis, proving that it is possible for horizontal spillovers to generate negative influence on productivity level and yet a positive effect on productivity growth rate of domestic firms in host country via the channel of learning investment.

From here onwards, the paper is organized as follows: Section 2 provides a brief review of theories of productivity spillovers, while Section 3 considers the preliminary discussion about intra- and inter-industry spillovers from the perspective of learning cost. Theoretical framework in Section 4 offers a basis for empirical model to be discussed. Details about data is in Section 5. Empirical findings in correspondence with theoretical analysis are presented in Section 6. The paper concludes with Section 7.

2. Literature Review

People are in favor of FDI, because it can be used as a way to generate employment in recipient countries. A more sophisticated argument is that FDI increases capital stock and thereby allows wages to rise. Besides the widely accepted opinion that foreign invested firms pay their way, bringing investment and creating new employment opportunities which boosts economic growth in host countries, policy makers and academics are more interested in figuring out whether FDI can be a source of valuable productivity externalities through linkages and spillover effects to indigenous firms.

2.1 Empirical Research

One general conclusion that emerges from existing literature is that the empirical evidence on examining the existence of positive impacts produced by MNEs is ambiguous. The picture is gloomier in the case of under-developed countries. Most of the preceding literature, such as the well-developed analysis with careful econometric techniques done by Haddad and Harrison (1993) on Morocco, Aitken and Harrison (1999) on Venezuela, Javorcik and Spatareanu (2008)
on Romania, not only failed to detect the presence of positive productivity effects, but even found depressing evidence of negative influence.

Employing a panel of Mexican manufacturing plants over the period 1993-1999, Lopez Cordova (2002) observes negative intra-industry spillovers. Using worker mobility as a possible channel for spillover effects, Gorg and Strobl (2005) fail to find any positive effects on firm level productivity. In a survey of studies using panel data sets made by Grog and Greenaway (2002), only two studies for developed countries and non for developing countries show positive spillovers and the results of all other studies are either negative or insignificant.

Empirical estimation results generally shed pessimistic evidence on productivity enhancing effect of FDI which is in stark contrast with traditional expectation. Therefore some researchers started wondering that maybe they have been looking for positive FDI spillovers in the wrong place. Realizing the fact that multinationals have incentive to minimize technology leakages which would enhance the performance of their local competitors while benefiting from transferring knowledge to their local upstream suppliers, people gradually form the idea that rather than horizontal linkages, vertical linkages are more likely to be the significant channel for dissemination of FDI’s positive spillover effects. As a result, inter-industry linkages appeared on the scene.

Nowadays, it has been the mainstream for empirical analysis to explore the existence of desirable spillover effects from multinationals to domestic firms in upstream or downstream industries. By doing so, estimation results become more encouraging than before. With industry-level panel data for 10 manufacturing industries in Colombia during 1974-1998, Kugler (2001) performs an analysis by distinguishing between horizontal and vertical spillovers. Widespread evidence for positive inter-industry spillovers are reported, but intra-industry spillovers are only found in the sector of machinery equipment. In a well-developed work made by Lopez-Cordova (2003), spillovers through vertical linkages are considered based on firm-level panel data for Mexico for 1993-2000. It is reported that foreign capital improves total factor productivity, with
positive inter-industry spillover effect prevailing over an adverse intra-industry effect. Subsequent works, such as Javorcik on Lithuania (2004), Blalock and Gertler on Indonesia (2008), Liu, Liu and Zhang on China (2009), Javorcik and Spatareanu on Romania (2011), all reach a similar conclusion, suggesting positive effects from vertical linkages while negative or insignificant impacts from horizontal linkages.

2.2 Theoretical Analysis

Compared with a vast amount of empirical analysis, theoretical work in this field still has plenty of room for improvement. So far, existing literature has been developed mainly around the topics such as FDI determinants, possible channels for spillover effect dissemination and so on.

While Vernon’s (1966) product cycle model assigns a central role to FDI, capturing his idea, a number of models cast imitation as the channel of international technology transfer from an innovating country (generally the industrialized country) to an imitating country (developing country)\(^6\). Viewing labor mobility as a potential channel, Glass and Saggi (2002) construct an oligopoly model in which a foreign invested firm has superior technology compared to local firms. They contribute to the existing analytical framework by implying two possible rationales for attracting FDI: since workers employed by MNEs acquire its superior technology, thus such technology may diffuse to local firms if they hire worker who have worked in foreign affiliates; also workers can benefit from wage premiums provided by MNEs. Markusen and Venables (1999) give one possible answer to the question “How does an FDI project affect local firms in the same industry” from the perspective of competition effects along with linkage effects, and show how it is possible for FDI to act as a catalyst, helping the development of local industry.

Consistent with the development of empirical studies, a few recent theoretical analyses also start paying attention to the input-output vertical linkage. One of the pioneer theoretical studies that explore the effects of knowledge diffusion on the incentive for technology transfer in a

\(^6\) See Krugman (1979), Helpman (1993), and Lai (1998).
vertical relationship is Pack and Saggi’s work (2001). They show that externalities generated by MNEs in downstream industries benefit indigenous firms by transferring the technology as it can induce competition among suppliers.

According to the above summary of preliminary literature investigating spillover effects of FDI, we realize that although some theoretical frameworks have been built to explain the mechanism of horizontal spillovers and vertical spillovers respectively, little effort has been made to unpuzzle the issue that why there exist negative spillover effects through intra-industry linkages rather than inter-industry linkage. Ironically, it is the issue that empirical literature emphasizes a lot.

3. Preliminary Discussion from the Perspective of Learning Cost:

   Horizontal Spillover Effects vs. Vertical Spillover Effects

   Most standard models of FDI assume multinational firms possess some special assets, usually the knowledge assets such as production technology, improved organizational and managerial skills, and marketing know-how. Multinationals enjoy such technological advantages so that they could compete with domestic firms on the latter’s own turf. Knowledge assets are believed to be the secret weapon for MNEs in the competition with indigenous firms who are more familiar with local market, possess complete supply chains and even have honest consumers of their own. When a foreign affiliate enters the local market, it is possible that some of its knowledge will spill over to domestic firms through the interaction with them. This is why the presence of MNEs is always considered to be the source of positive spillovers to domestic firms.

   3.1 Horizontal Spillover Effects

   Horizontal spillovers occur when the presence of foreign affiliates enhances the productivity of local firms in the same sector. Generally, there are three main channels for technology dissemination through intra-industry linkages: imitation/ demonstration, labor mobility and competition. Ideally, if these channels work well, without any doubt, FDI can be viewed as a
powerful engine for productivity growth, then there is no point for us to rack our brains writing this paper. Unfortunately, in the real world things are more complicated.

As Kugler (2001) discussed in his paper, multinationals come to a new market all the way from their parent country not for generously helping the local firms with their productivity improvement. Maximizing profit is their sole and ultimate goal. Therefore, it is unlikely to be in the interests of MNEs to voluntarily share their firm specific advantages with domestic rivals. Quite the contrary, they will set up barriers to limit such spillovers as much as possible.

To prevent knowledge leakage from taking place, MNEs will not give a comprehensive manual on goods production methods or management procedure to domestic firms. As foreign firms’ knowledge is often tacit or embodied in a product or process, therefore not openly accessible to local firms. The scenario which is more likely to happen is that given the final goods produced by MNEs, local firms ask some workers, which could have been devoted to physical goods production, to figure out how to imitate the new production technique. This process is the so-called reverse engineering. The same principle applies to managerial and organizational innovations too, even though they may be easier to imitate. Taking this into account, here we can make a rational conjecture that getting new production techniques from foreign rivals is costly, the more complex the products or processes are, the higher learning cost it will be. And how much resources should be devoted to learning is essentially an investment decision.

The acquirement of sophisticated technology requires investment by domestic firms in terms of time and effort. This kind of investment activity, although enhances firms’ future productive capacity, diverts managerial time, effort and other limited resources away from current physical goods production, leading to a decrease in current output. Such resources devoted to learning new technology can be seen as some sort of human capital in spirit.
3.2 Vertical Spillover Effects

Backward spillovers refer to the technology transfer through supply chain from MNEs in the downstream to their upstream local intermediate input suppliers. There is a rationale reason for the presence of vertical spillovers. As a number of authors have argued in their work, MNEs may transfer technology to their suppliers deliberately as a strategy to build up efficient supply chains for overseas operations, since doing this can lower the cost of physical inputs for multinationals.

The primary reason for foreign invested firms to provide technical assistance to suppliers is for the sake of intermediate products with higher quality and lower prices. Lall (1980) notes that multinationals might transfer knowledge to local firms in upstream in three ways: to help prospective suppliers set up production capacities; to provide assistance to raise the quality of suppliers’ products and to facilitate innovations; to provide labor training and help in management, organization.

We can gain a better understanding of what happens through the vertical linkages in the real world by some anecdotal evidence. In Malaysia, foreign investors helped their local sub-contractors keep pace with modern technologies by assigning technicians to the suppliers’ plants to help set up and supervise large-volume automated production and testing procedures. After a Czech producer of aluminum alloy castings for the automotive industry signed its first contract with a multinational customer, staff from the multinational would visit the Czech firm’s premises for two days each month over an extended period to work on improving the quality control system. Then the Czech firm applied these improvements to its other production lines and reduced the

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7 Again in this paper we refer to vertical spillovers as backward spillovers. Note that forward spillovers which occur when domestic firms gain access to new or cheaper intermediate inputs due to the presence of MNEs in the upstream belong to vertical linkages as well. However as backward linkages are more robust and significant in empirical studies, here we only focus on backward spillovers.


9 See Moran (1998)
number of defective items produced\textsuperscript{10}. Extensive interviews have been done in Korea. Through visits to their plants by engineers or other technical staff of the foreign buyers, through visits by their engineering staff to the foreign buyers, through the provision of blueprints and specifications, through information on production techniques and on the technical specifications of competing products, and through feedback on the design, quality and technical performance of their products, most of the interviewed Korean firms said they had directly benefited from the technical information foreign buyers provided\textsuperscript{11}.

From these aforementioned characteristics of inter-industry spillovers, we can conjecture that there is unlikely to be a significant amount of learning cost in benefiting from vertical spillovers compared with the intra-industry level learning process. A clarification must be made here to avoid generating unnecessary confusion and to make our theory more reasonable: we do not deny the existence of basic costs for acquiring new technology no matter from the foreign affiliates in the same sector or in the downstream sector. However as the primary interest of this paper is to address the issue why different from vertical spillovers, horizontal spillovers are negative, and what is the underlying mechanism for horizontal spillovers to generate adverse effects, hence we need to look for the distinctions lying in the characteristics of them. From the perspective of learning cost and based on the properties of horizontal/vertical spillovers, we draw the conclusion that horizontal spillovers may incur substantial amount of learning costs, whereas learning costs in vertical spillovers are comparatively minor or even negligible. In other words, to acquire superior technology from within-industry MNE subsidiaries, local firms are faced with a learning investment decision.

\textsuperscript{10} See Javorcik (2004)

\textsuperscript{11} See Rhee, Ross-Larson and Pursell (1984)
4. Theoretical Model

Based upon the fundamental assumption of learning cost, in this section, we set out to discuss the issue of our interest theoretically. In our model, domestic firms are allowed to have technology transfer both from foreign invested firms in the same sector and downstream sector. Knowledge transferred through vertical linkage is denoted by $V_t$. It is an exogenous variable, since the amount of $V_t$ is determined by MNEs rather than domestic firms themselves. When foreign consumers increase, knowledge provided for the upstream local suppliers will rise correspondingly. Thus the variable $V_t$ can be considered as a proxy for the presence of foreign invested firms in downstream sector. Adjustable firm specific knowledge assets $H_t$ are obtained from MNEs operating in the same sector. This variable is endogenous, indicating that domestic firms can choose quantity and quality of the technology provided by multinationals via deciding how much learning investment they are going to make\textsuperscript{12}. Production technique with larger quantity or higher quality incurs larger learning cost and consequently needs domestic firms to devote more resources for acquisition. Furthermore, we assume the engine of growth is firm specific knowledge asset, which augments productivity of all inputs. Then the production function is specified as

$$Q_t = A V_t K_t^\alpha [L_t(1 - I_t)]^\beta H_t^\varepsilon$$

where $A, K_t, L_t$ are the basic components of a standard Cobb-Douglas production function. $A$ represents firm specific factor which does not change along with time. $K_t, L_t$ are capital and labor inputs respectively. Since we argue that absorbing new technology through horizontal linkages calls for reverse engineering, local firms need to sacrifice some proportion of the human capital which could have been used to conduct productive activity. Now, in order to have access to new technology, some human capital is taken away from production activity, resulting in a reduction in labor force. $I_t$ represents the learning investment. More specifically speaking, in this current model it is a fraction of labor resource engaged in acquiring new technology. Thus, $L_t(1 - I_t)$ is the amount of labor input chosen by each firm to conduct physical

\textsuperscript{12} The principle idea here is that technology transfer through intra-industry linkages does not take place automatically and it is a costly learning process.
goods production. Consequently, $Q_t$ is the net output after taking learning cost into account. In addition, we assume the elasticity of firm specific knowledge asset $\varepsilon$ is bigger than that of labor $\beta$ and $\alpha + \beta + \varepsilon = 1$.

The accumulation of firm specific knowledge comes from three sources. First, it requires learning investment $I_t$. The economic intuition is straightforward: active learners who are willing to sacrifice more for learning investment will correspondingly acquire more advanced production technique. The second source is denoted by $G_t$, representing the presence of MNEs that carry out productive activity in the same sector. Since it is the multinationals who possess superior technology, without them no matter how much local firms are willing to invest, there would be no knowledge transfer. Obviously, the accumulation of $H$ changes along with $G$. However still it is not enough only with $I_t$ and $G_t$. As a number of theoretical as well as empirical studies have argued, if technic skills of indigenous firms do not reach a certain level, absorbing state-of-the-art technology from MNEs remains tantalizingly out of reach. Hence it is very necessary to think about the firm’s ability to convert knowledge from the public pool into themselves. The current stock of firm’s specific knowledge asset $H_t$ is proper to proxy its technical capability. Given these three sources, production of firm specific knowledge asset is defined as

$$H_{t+1} = (1 + hI_tG_t)H_t$$

where $h$ is an efficiency parameter and there is no depreciation in $H$.

Therefore, in this model the accumulation of firm specific knowledge assets competes with the production of physical goods for human capital. Apparently there is a tradeoff: even though expanding investment for new technology in current period will reduce contemporaneous production, meanwhile it can augment the firm specific assets of next period leading to higher output in that period. Taking future profit into account, domestic firms carefully choose the amount of investment and other intermediate input, so that the present value of their profit stream can be maximized.

Based on the previous discussion, the firm profit maximization problem is defined as
Max \( \pi = \sum_{t=0}^{\infty} \delta^t \{ Q_t - (w_tL_t + \bar{r}K_t) \} \)

s.t. \( H_{t+1} = (1 + hI_tG_t)H_t \)

where \( \delta \) is discounting rate, \( \alpha + \beta + \varepsilon = 1 \) and \( \varepsilon > \beta \). Note that \( w_tL_t + \bar{r}K_t \) stands for production cost. \( w_t \) is real wage which is assumed to grow at a constant rate \( g \). The assumption of small country is introduced, implying that interest rate (\( \bar{r} \)) is not affected by domestic policies.

Derive Bellman Equation

\[
V(H_t) = \max\{AV_tK_t^\alpha L_t^\beta H_t^\varepsilon (1 - I_t)^\beta - (w_tL_t + \bar{r}K_t) + \delta V(H_{t+1})\}
\]

The standard optimal control procedure yields the following first order necessary conditions:

\[
\frac{K_{t+1}}{K_t} = \frac{Q_{t+1}}{Q_t} \quad (1)
\]

\[
\frac{L_{t+1}}{L_t} = \frac{Q_{t+1}}{Q_t} \frac{1}{1 + g} \quad (2)
\]

\[
\frac{\beta Q_t}{1 - I_t} = \delta V'(H_{t+1})hG_tH_t \quad (3)
\]

Envelop condition for the maximization problem is

\[
V'(H_t) = \frac{\varepsilon Q_t}{H_t} + \delta V'(H_{t+1})(1 + hI_tG_t)
\]

Euler Equation is obtained from first order condition and envelop condition

\[
\frac{Q_{t+1}}{Q_t} = \frac{\beta (1 - I_{t+1})G_{t+1}H_{t+1}}{(1 - I_t)\delta G_tH_t[\varepsilon hG_t + \beta + hG_{t+1}I_{t+1}(\beta - \varepsilon)]} \quad (4)
\]

From production function

\[
\frac{Q_{t+1}}{Q_t} = \left( \frac{K_{t+1}}{K_t} \right)^{\alpha} \left( \frac{L_{t+1}}{L_t} \right)^\beta \frac{V_{t+1}}{V_t} (1 + hI_tG_t)\varepsilon \left( \frac{1 - I_{t+1}}{1 - I_t} \right)^\beta \quad (5)
\]
Substituting (1), (2), (4) into (5), we arrive at the following expression:

\[ \beta^e G_{t+1}^e (1 - I_{t+1})^{e-\beta} = \delta^e G_t^e (1 - I_t)^{e-\beta} [eh G_{t+1} + \beta + hG_{t+1}I_{t+1}(\beta - \varepsilon)]^\varepsilon \left( \frac{1}{1 + g} \right)^\beta \frac{V_{t+1}}{V_t} \] (6)

Denote this equation by \( F \),

\[ \frac{\partial F}{\partial I_t} = \delta^e G_t^e (\varepsilon - \beta)(1 - I_t)^{e-\beta-1} [eh G_{t+1} + \beta + hG_{t+1}I_{t+1}(\beta - \varepsilon)]^\varepsilon \left( \frac{1}{1 + g} \right)^\beta \frac{V_{t+1}}{V_t} > 0 \]

\[ \frac{\partial F}{\partial G_t} = -\varepsilon \delta^e G_t^{e-1} (1 - I_t)^{e-\beta} [eh G_{t+1} + \beta + hG_{t+1}I_{t+1}(\beta - \varepsilon)]^\varepsilon \left( \frac{1}{1 + g} \right)^\beta \frac{V_{t+1}}{V_t} < 0 \]

\[ \frac{\partial F}{\partial \left( \frac{V_{t+1}}{V_t} \right)} = -\delta^e G_t^e (1 - I_t)^{e-\beta} [eh G_{t+1} + \beta + hG_{t+1}I_{t+1}(\beta - \varepsilon)]^\varepsilon \left( \frac{1}{1 + g} \right)^\beta < 0 \]

given \( \alpha + \beta + \varepsilon = 1 \) and \( \varepsilon > \beta \). Such procedures enable us to apply Implicit Function Theorem.

**Proposition 1.** *The increase of foreign affiliates no matter in the current period or in the future will boost the learning investment made by domestic firms operating in the same sector.*

Since the expansion of foreign invested firms increases marginal benefit of contemporaneous learning investment made by local firms, as a result, investment for new production technology in period \( t \) moves in the same direction as the presence of MNEs in the same period. Expressed by formula, \( \frac{\partial I_t}{\partial G_t} = - \frac{\partial F}{\partial G_t} \frac{\partial F}{\partial I_t} > 0 \).

In infinite-period real world, firms usually take the long view: when domestic firms decide how much to invest for new production technique today \( (I_t) \), they may probably not only depend on the current presence of MNEs \( (G_t) \) but also take the future changes of foreign affiliates \( (G_{t+1}) \) into consideration as well. The presence of multinationals in period \( t+1 \) is positively correlated with the learning investment made by domestic firms in period \( t \). Mathematically, it is obtained
by \( \frac{\partial I_t}{\partial G_{t+1}} = -\left( \frac{\partial F}{\partial I_t} \frac{\partial I_{t+1}}{\partial G_{t+1}} \frac{\partial F}{\partial G_{t+1}} \right) > 0 \).

Proposition 2. As to vertical linkage, the current presence of foreign invested firms in the downstream sector adversely affects the amount of learning investment made by local firms. However, upstream local suppliers will have a strong incentive to conduct investment activity for technological progress when the amount of downstream foreign affiliates increases in the future.

According to implicit function theorem, 
\[
\frac{\partial I_t}{\partial V_{t+1}} = -\frac{\frac{\partial F}{\partial I_t}}{\frac{\partial F}{\partial V_t}} > 0, \text{ implying that } \frac{\partial I_t}{\partial V_t} < 0
\]
and \( \frac{\partial I_t}{\partial V_{t+1}} > 0 \). \( V \) is the superior technology transferred through vertical linkage, and it also proxies the presence of MNEs in downstream sector as we discussed earlier. There is a reciprocal relationship between learning investment and the contemporaneous presence of downstream multinationals, namely \( V_t \). Due to the production function \( Q_t = AV_tK_t^\alpha[L_t(1 - I_t)]^\beta H_t^\epsilon \), when \( V_t \) increases, it leads to an increase in firm’s productivity. Therefore now in order to conduct an extra unit of learning investment, firms need to suffer from larger output losses. Briefly put, the opportunity cost for learning investment becomes higher due to the increase in \( V_t \). As a result, \( V_t \) exerts negative impacts on \( I_t \) via marginal cost of \( I_t \). On the other hand, future \( V \), namely \( V_{t+1} \), produces positive impacts on current learning investment by affecting marginal benefit of \( I_t \). By investing for new technology, the firm specific assets of next period (\( H_{t+1} \)) increase. Also, when \( V_{t+1} \) increases, the return from \( I_t \) will correspondingly become higher. Therefore \( V_{t+1} \) and \( I_t \) change in the same direction.

As all necessary conditions have been derived, now we take a look at how a change in \( G_t \) and \( V_t \) affects the productivity level (\( TFP_t \)) and growth rate (\( g_{TFP_t} \)).

\[
TFP_t = \frac{Q_t}{K_t^\alpha L_t^\beta} = AV_tH_{t-1}^\epsilon(1 + h_{t-1}G_{t-1})^\epsilon(1 - I_t)^\beta
\]

\[13\] By expanding the equation on numerator, we can readily determine its sign, which is negative. Since the derivation is tedious and not of great importance, I do not present the whole process here.
\[ g_{TPP_t} = \frac{TPP_{t+1} - TFP_t}{TPP_t} = \frac{V_{t+1}}{V_t} (1 + h_I G_t)^\varepsilon \left( \frac{1 - I_{t+1}}{1 - I_t} \right)^\beta - 1 \]

**Proposition 3.** MNEs in the downstream sector generate productivity enhancing effects by affecting learning investment of indigenous firms. The productivity promoting effects generated by foreign affiliates in horizontal linkage is not clear, but at least the case of being negative cannot be excluded.

Positive vertical spillover effects can be easily proved by differential equation \( \frac{dTPP_t}{dV_t} > 0 \). But the sign of \( \frac{dTPP_t}{dG_t} \) is unclear, because there are two opposite effects functioning at the same time: \( \frac{dTPP_t}{dG_t} = \frac{\partial TFP_t}{\partial I_t} \frac{\partial I_t}{\partial G_t} + \frac{\partial TFP_t}{\partial I_{t-1}} \frac{\partial I_{t-1}}{\partial G_t} \). The term of \( \frac{\partial TFP_t}{\partial I_t} \frac{\partial I_t}{\partial G_t} \) is negative. Without thinking about future, domestic firms enlarge their investment for firm specific knowledge assets as a response to the expansion of foreign affiliates operating in the same sector. Doing so leads to a decrease in productivity. But in the real world, decisions of learning investment in present period may also depend on the future presence of multinationals \( \left( \frac{\partial I_t}{\partial G_{t+1}} > 0 \right) \). Since the amount of investment in period t-1 decides firm’s specific knowledge asset in period t, there is an underlying positive correlation between \( G_t \) and \( H_t \) via \( I_{t-1} \) as their medium. Therefore \( \frac{\partial TFP_t}{\partial I_{t-1}} \frac{\partial I_{t-1}}{\partial G_t} \) is positive. Whether \( \frac{dTPP_t}{dG_t} \) is positive or negative depends on the magnitude of these two aforesaid terms. The good news is at least there exists a possibility that \( \frac{dTPP_t}{dG_t} \) takes negative sign, which fits perfectly the evidence observed in most of the developing countries.

**Proposition 4.** Although horizontal linkages between foreign affiliates and their domestic rivals take learning investment as a vehicle to generate negative effect on productivity level of local firms, it is just a temporary phenomenon.

For investigation on the duration of negative effects through horizontal linkages, we employ the idea of growth rate. Increase in learning investment will augment domestic firms’ specific
knowledge assets and consequently raise productivity growth rate, \( \frac{d\delta TFP_t}{dG_t} > 0 \). As a result, indigenous firms benefit from a steeper path of productivity growth. Therefore at some point in the future, local firms will recover from the initial productivity loss and thereafter the net effect of horizontal spillovers is positive and keeps growing overtime, indicating that the adverse impacts on productivity is not long-lasting.

From this model, we form a preliminary opinion to the two questions put forward at the beginning of this paper: horizontal spillovers may probably take learning investment as a channel to generate negative effects on productivity of indigenous firms in some developing countries. And through the channel of learning investment, although the expansion of multinationals exerts detrimental influence on current productivity level, it propels domestic firms to a steeper path of productivity growth.

5. Data Description

In last section, we explored the medium through which negative horizontal spillovers and positive vertical spillovers may be materialized by focusing on learning investment, and probed how the extent of foreign invested firms’ presence affects productivity growth rate of their domestic competitors. Now we set out to examine whether our findings are warranted from the aspect of empirical analysis by utilizing panel data of 37 manufacturing industries over the period from 2003 to 2012 in China.

The main data for this research, which span the population of Chinese industrial enterprises above designated size\(^{14}\), are drawn from China Statistical Yearbook, China Industry Economy Statistical Yearbook, China Statistical Yearbook on Science and Technology and Statistics on Science and Technology Activities of Industrial Enterprises published by China Statistic Press.

\(^{14}\) Industrial enterprises above designated size is referred to all the state-owned, and non-state-owned industrial enterprises with the annual sales revenue of over 5 million Yuan.
To eliminate influences of price fluctuation, correlative price indexes are utilized. All price indexes used in this paper are drawn from Chinese Statistical Yearbook\textsuperscript{15}. Our sample spans the period from 2003 to 2012 and includes data for 37 two-digit manufacturing industries each year\textsuperscript{16}. The data contain information about output value, value added, labor, original value of fixed assets, net value of fixed assets, personnel engaged in R&D.

### 5.1. About Learning Investment, Labor and Capital Stock

Personnel engaged in R&D sector is the proxy for learning investment level. Since in theoretical framework $I_t$ is the ratio between human capital devoted to acquiring new production technique and the total labor force, we measure this variable by using personnel-engaged-in-R&D-to-labor-ratio. Labor is measured by total number of employees rather than labor hours because of data limitation.

To measure the real capital stock, we adopt a method which is very close to perpetual inventory method developed by Chow (1993). Perpetual inventory method requires historical information on annual gross investments. Due to data constraint, we can only adopt a similar approach by treating the deflated net value of fixed assets in 2003 (the initial year in our dataset) as the initial real capital stock. This kind of treatment is similar to Lichtenberg (1992). Then we derive the value of newly added fixed assets by taking difference in original value of fixed assets between the current and preceding year. Given the initial real capital stock, we use perpetual inventory method to measure capital stock in year $t$ as

$$K_t = (1 - d)K_{t-1} + I_t$$

\textsuperscript{15} Producer price index for manufactured goods, purchasing price index for raw material, fuel and power, price index for investment in fixed assets are used to deflate in the current research.

\textsuperscript{16} There are 39 two-digit manufacturing industries in total. However the problem of missing data is very serious in mining of other ores and recycling and disposal of waste. Hence we exclude these two industries from our dataset.
where \( d \) is the depreciation rate. In the same fashion with Young (2000), we assume that the depreciation rate is 6%. To check robustness, we also apply different depreciation rates, 7%, and 10%, following Liu (2008).

### 5.2 Proxies for Spillovers

A longstanding measurement of horizontal FDI is used in this literature: the share of an industry’s output produced by foreign affiliates\(^{17}\). Specifically,

\[
G_{it} = \frac{\text{Foreign\_Output}_{it}}{\text{Output}_{it}}
\]

Each industry is represented by sub-index ‘\( i \)’ and ‘\( t \)’ indexes the different years in the time frame. In line with notations in preceding theoretical model, \( G_{it} \) captures the presence of foreign invested firms in the same sector.

While measurement of horizontal FDI is straightforward, the presence of foreign affiliates in downstream is complicated. Following Javorcik (2004), Blalock and Gertler (2008), we define the proxy for it as

\[
V_{it} = \sum_{j \neq i} \alpha_{ij} G_{jt}
\]

where \( \alpha_{ij} \) is the proportion of sector \( i \)’s output supplied to sector \( j \) taken from the input-output tables. This variable is intended to capture the extent of potential contacts between domestic suppliers and multinational consumers. The greater the foreign presence in sectors supplied by industry \( i \) and the larger the share of intermediates supplied to industries with a multinational presence is, the higher the value of \( \alpha_{ij} \) will be.

Since relationship between sectors changes over time, multiple input-output tables are used. For \( V_{it} \) in 1999, we utilize I-O table of 1997; for \( V_{it} \) in 2000 to 2003, I-O table of 2002 is used;\(^{17}\) This measurement method follows Blalock and Gertler (2008), Javorcik and Spatareanu (2008), Javorcik and Spatareanu (2011).
2005 I-O table is for $V_{it}$ in 2004 and 2005; 2007 I-O table is for $V_{it}$ in 2006 to 2008; for the recent 4 years’ $V_{it}$, we use 2010 I-O table.

5.3 Measurement for TFP

Before stepping into our main discussion of panel data estimations, another preparatory work is indispensable – measuring total factor productivity (TFP). The traditional OLS approaches to estimate TFP may suffer from some potential problems which make estimation results unreliable. For example, validity of OLS requires that the inputs in the production function are determined exogenously. However, in reality things may not work so well as what has been assumed theoretically. As Griliches and Jacques Mairesse (1995) argued, in practice, it is more appropriate to consider input as endogenous, in that the quantity of inputs are chosen by firms based on its productivity which is observed by producer but not by econometrician. Thus very likely the orthogonality condition fails to hold, leading to bias in the TPF estimation.

To tackle the endogeneity bias, we employ a semi-parametric approach suggested by Levinsohn and Petrin (2003). The underlying idea is that there exists a relationship between unobserved productivity on the one hand, and observable intermediate inputs and capital on the other hand. Therefore, intermediate input is used to proxy unobserved productivity shocks.

6. Empirical Analysis

6.1 Estimation Results

Some essential conclusions are brought forth in preceding theoretical model: horizontal spillovers could possibly produce negative effects on productivity level via learning investment whereas vertical spillovers exert positive effects, and in spite of the unpleasing role that horizontal

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18 This method is first suggested by Olley and Pakes (1996), Levinsohn and Petrin made some modification by using intermediate input as proxy for productivity shock.
spillover plays in the case of productivity level, intra-industry linkages produce desirable influence on productivity growth rate. To keep consistency with our findings in theoretical work, the empirical estimation is carried out in two steps.

6.1.1 Evidence for the Channel

Since we argue it is horizontal linkages rather than vertical linkages that takes learning investment as a medium to generate negative effects, therefore in this subsection, we seek to check the reliability of this argument by regressing learning cost on foreign presence in the same sector and in downstream sectors.

From equation (6) in the multi-period model,

$$\beta^e G_{t+1}(1 - I_{t+1})^{e-\beta} = \delta^e G_{t}(1 - I_{t})^{e-\beta}[\epsilon hG_{t+1} + \beta + hG_{t+1}I_{t+1}(\beta - \epsilon)]^\epsilon (\frac{1}{1 + g^\epsilon})^\beta \frac{V_{t+1}}{V_t}$$

it can be observed that learning investment is affected by three factors: the current presence of MNEs in the same sector $G_t$, the future extent of multinationals’ presence $G_{t+1}$, the last one is $V_{t+1}/V_t$.

Based this, the first regression equation is

$$I_{it} = \beta_0 + \beta_1 G_{it} + \beta_2 G_{it+1} + \beta_3 \frac{V_{i,t+1}}{V_{it}} + \epsilon_{it} \quad (7)$$

If our statement is true, then estimated coefficients on $G_t$, $G_{t+1}$ and $\frac{V_{t+1}}{V_t}$ should be significantly positive.

Table 1 reports estimation results for equation (7). Two situations are considered: with or without time dummy. The first two columns show the case without time dummy, and column 3 and 4 present the results when time dummy is included. As we expected, $G_t$ bears a positive and statistically significant coefficient all the time, implying that the presence of MNEs is positively correlated with the contemporaneous learning investment of their local competitors. Also the future increase of foreign affiliates in the same industry ($G_{t+1}$) will stimulate domestic firms to acquire more production technology.
$\frac{V_{t+1}}{V_t}$ doesn’t take positive sign unless time dummy is contained. Since in panel data analysis it is more appropriate to run regression with time dummy, we focus on the last two columns. Results for both random effects model and fixed effects model are presented in Table 1. Hausman test goes to random effects model which is exhibited in column 3. Generally, these results are consistent with our preceding theoretical discussion. Even though the explanatory power of $\frac{V_{t+1}}{V_t}$ is not as strong as that of $G$, still this term takes positive sign at a borderline significance level – 10%.

Based upon equation (7), if we construct regression equation more rigorously, it will take the following form

$$I_{it} = \beta_0 + \beta_1 G_{it} + \beta_2 G_{it+1} + \beta_3 V_{it} + \beta_4 V_{i,t+1} + \epsilon_{it} \quad (8)$$

This equation follows our theoretical analysis more closely. According to conclusions in Section 4, estimated coefficients on $G_{t}$, $G_{t+1}$ and $V_{t+1}$ should be positive while $V_{t}$ bears negative coefficient\(^{19}\). Table 2 exhibits estimation results for equation (8).

Similar results are obtained with the new regression equation. Again we focus on the last two columns where time dummy is included. $G_{t}$ and $G_{t+1}$ shows their robustness by presenting positive sign whatever the model is. But the other two terms, $V_{t}$ and $V_{t+1}$, are problematic. Because although their signs are just as what we have expected, the explanatory power is very weak: both of them in the case of random effects model (column 3) and $V_{t}$ in the case of fixed effects model (column 4) are not statistically significant. Fortunately, the result of F-test shows that $V_{t}$ and $V_{t+1}$ are jointly significant in both random effects model as well as fixed effects model. Therefore, estimation (7) and (8) reveal similar results.

\(^{19}\frac{\partial I_{it}}{\partial G_{t}} > 0, \frac{\partial I_{it}}{\partial V_{t+1}} > 0, \frac{\partial I_{it}}{\partial G_{t+1}} > 0, \frac{\partial I_{it}}{\partial V_{t}} < 0. \) See Section 3 for more details.
6.1.2 Productivity Level Effect and Growth Rate Effect

What we obtained in the first step estimation is very inspiring. They are successfully conforming to the theoretical expectations. Now that the first task has been finished, we set about the second step, looking into linkages between learning investment and productivity level together with growth rate. From the definition equation of total factor productivity of each firm

\[ TFP_t = \frac{Q_t}{K_t^\alpha L_t^\beta} = AV_t^e (1 - I_t) \beta \]

\[ = AV_t^e (1 + hl_{t-1}G_{t-1})^\varepsilon (1 - I_t) \beta \]

Take log of both sides,

\[ \ln TFP_t = \ln A + \ln V_t + \varepsilon \ln h_{t-1} + \varepsilon \ln (1 + hl_{t-1}G_{t-1}) + \beta \ln (1 - I_t) \]

Then take first difference,

\[ \Delta \ln TFP_{tt} = \ln TFP_t - \ln TFP_{t-1} \]

\[ = \ln V_t - \ln V_{t-1} + \varepsilon \ln (1 + hl_{t-1}G_{t-1}) + \beta \ln (1 - I_t) - \beta \ln (1 - I_{t-1}) \]

\[ = \ln V_t - \ln V_{t-1} + \varepsilon h_{t-1}G_{t-1} - \gamma I_t + \gamma I_{t-1} + \theta_t \]

(9)

Based on this, our second step estimation equation is

\[ \Delta \ln TFP_{tt} = \beta_0 + \beta_1 \ln V_{it} + \beta_2 \ln V_{i,t-1} + \beta_3 G_{i,t-1} + \beta_4 l_{it} + \beta_5 l_{i,t-1} + \epsilon_{it} \]

(10)

Parameter \( \beta_4 \) captures the effects of learning investment on productivity level, while \( \beta_5 \) captures its productivity growth rate effects.

As we have discussed before, if a firm does not care about future change in \( G_t \), then \( G_t \) will definitely generate negative effects on productivity through the channel of learning investment \( \left( \frac{\partial TFP_t}{\partial I_t} \frac{\partial I_t}{\partial G_t} < 0 \right) \). Once the firm considers about \( G_{t+1} \), consequently, the presence of multinationals in period \( t+1 \) may affect present learning investment and the amount of current learning.

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20 Note that the property of logarithm \( \ln(1 + x) \approx x \) is utilized here. Since I wrote “=” instead of “\( \approx \)”, an extra term \( (\theta_t) \) is added in the equation.
investment generates impact on knowledge asset stock in the following period, then ultimately affects productivity of period \( t+1 \). Briefly put, besides investment, the presence of foreign invested firms in the same sector may take firm specific knowledge asset \( H_t \) as another route to play its role and generates positive effects on productivity of local firms in host country \((\frac{\partial TFP_t}{\partial H_t} \frac{\partial H_t}{\partial I_{t-1}} \frac{\partial I_{t-1}}{\partial \sigma_t} > 0)\). Note that by taking first difference, equation (9) removes the positive effects exerted through the channel of \( H \).

In line with theoretical analysis, two opposite impacts are expected to be detected from learning investment on productivity level and growth rate respectively. If our theory works well, estimated coefficient on \( I_t \) (level effect) will be negative whereas that on \( I_{t-1} \) (growth rate effect) is positive. Table 3 reports estimation results for equation (10).

The dependent variable is first difference of log-form TFP calculated by different depreciation rates. Estimation results do not change severely whether time dummy is include in regression equation or not, therefore in Table 3 we only show the cases with time dummy. No matter how the depreciation rate varies, estimated coefficient on \( I_t \) is always negative at 1% significant level, implying that in the case of China learning investment adversely affects productivity level of indigenous firms. About productivity growth rate, although the estimated coefficient on \( I_{t-1} \) is always positive, which matches our expectation well, it does not possess too much explanatory power in fixed effects model. However since Hausman test favors random effects model, in which estimates are all statistically significant at 5% level, by and large we can draw a conclusion that domestic firms’ learning investment speeds up their productivity growth.

What we observed in Table 3 lends support to our theoretical corollary. The presence of foreign-invested firms operating in the same sector has significant but opposite effects on level and growth rate of indigenous firms’ productivity. Take the case in which TFP is calculated bases on 10% depreciation rate for example. The level effect, -2.105, implies that when learning investment increases 0.01, then the productivity level would correspondingly fall by 2.105%. The rate effect, 1.661, suggests that the rate of productivity growth would increase by 1.661% in response to 0.01
increase in learning investment. Combining these two results together, we can say that the increase in productivity growth rate will enable domestic firms to recover from the initial productivity loss in nearly 1.27 years, and thereafter the net effect of horizontal externalities is positive and keeps growing.

6.2 Robustness Checks

We subject our results to several robustness tests. First, we check whether the expected pattern in step one still holds if we use a new measurement to capture the presence of foreign invested firms. Following Aitken and Harrison (1999), the presence of foreign investment is redefined by using employment weights.

\[ G_{it} = \frac{\text{Foreign employment}_{it}}{\text{Total employment}_{it}} \]

Accordingly, \( V_{it} \) needs to be recalculated based upon the newly defined \( G_{it} \). Estimates can be found in Table 4.

In the case that time dummy is included, Hausman test goes for fixed effects model where the three independent variables are positively correlated with \( I_t \). Hence we prove the validity of our first step baseline results.

To check reliability of the preceding second step estimation, we adopt a new measurement for capital stock to estimate TFP. Zheng (1992), Li and Zhu (2006) employed deflated annual average balance of net value of fixed assets as capital stock in their works. Utilizing the same idea, we recalculate TFP. Table 5 reports regression results with such newly estimated TFP as explained variable.

Unsurprisingly, significantly negative sign shows up in front of \( I_t \) either in the case of random effects model or fixed effects model. The estimated coefficient on \( I_t \) possesses strong explanatory power at 1% significance level all the time. Also there is evidence for the positive effect generated by horizontal spillovers on productivity growth rate of local firms, in that estimated coefficients
on $I_{t-1}$ are positive. Hausman test suggests random effects model is better compared with fixed effects model. In random effects model, no matter time dummy is included or not, estimated coefficients on $I_{t-1}$ are always statistically significant.

### 6.3 Limitations and Future Research

In the second stage estimation, there may exist endogeneity problem, since for those industries who are suffering from low productivity level, they probably resort to technology innovation as a solution to productivity malaise. In other words, it is the low productivity level that brings about high learning investment not the other way around. This problem will lead to biased estimates in empirical analysis. Due to industry-level data in this paper, it is difficult to find proper instrumental variables. Firm-level data could be an optimal choice for my future research to avoid such potential problems.

In our preceding theoretical analysis, we can observe that for most of the time it is $\frac{V_{t+1}}{V_t}$ that plays a role in the whole system. In other words, the growth rate of $V$ could be another crucial factor in our discussion of the impacts generated by MNEs on domestic firms’ performance. In this paper, we fail to discuss this issue in depth since more attention is focused on explaining why horizontal spillovers exert undesirable effects and detecting the duration this negative effect. In order to construct a more complete theoretical system, it is necessary to put discussions about the growth rate of $V$ on future research agenda.

We limited our attention on learning investment as the only vehicle for spillovers to generate effects. However it cannot be denied that there could possibly exist some other channels. Further research is needed so that we can form a better understanding about the mechanism of spillover effects from MNEs and find good policy measures to ensure the maximum utilization of FDI.
7. Conclusion

This paper is built upon the emerging literature about spillover effects generated by foreign direct investment on productivity gain of recipient countries. Numerous empirical studies have explored the linkage between foreign investment projects and indigenous firms. They get a similar conclusion that, for most of the cases horizontal spillover effects are either negative or insignificant, whereas positive productivity spillovers from FDI are more likely to take place through vertical linkages.

Even though a handful of studies have been done in order to elaborate the negative horizontal spillover effects, most of them tend to analyze this issue by taking horizontal spillovers as the only research object. This paper gains a new insight by thinking about the negative horizontal spillovers together with positive vertical externalities. Hence we set out to offer one reasonable explanation for these two opposite impacts from a new point of view – the existence of learning costs.

Besides this, we take one step further getting to the bottom of the true effects of horizontal spillovers on productivity development of local firms. Our second step research is motived by the dichotomy between empirical economics literature and international business theory. Although there are ample empirical evidence for the undesirable horizontal spillover effects, theoretical research in this field offers a myriad of views stating the potential benefits from intra-industry FDI and neither of the views can be ruled out. The big diverging results imply that there may be an erroneous inference about horizontal spillovers. Something important must be neglected by most researchers so that the true productivity enhancing effect of horizontal spillovers is still hidden in dark. Therefore, we seek to investigate this issue from the perspective of growth rate.
Starting from a theoretical framework with our basic assumption of learning costs, we stress two key insights. One is that horizontal spillovers may take learning investment as a medium to exert negative effect, however vertical spillovers behaves in just opposite way. This could be one possible reason to explain the two opposite spillover effects. The other conclusion is even though horizontal externalities have a detrimental effect on productivity level of domestic firms, a hidden positive effect on productivity growth rate is also there. This finding is very inspiring. It implies that negative horizontal spillover effect is a temporary phenomenon. Domestic firms can recover from the initial productivity loss and be propelled to a steeper productivity growth path. Specifically, the possible negative level effects underpin our assumption that technology acquirement is a costly process: firms need to sacrifice some proportion of their production resources in order to have access to the superior production technique. Meanwhile the positive growth rate effects imply that technology transfer enhance future productivity capacity of local firms.

To further prove the plausibility of our analysis, an empirical estimation with China’s industry-level penal data over a period 2003-2012 is included in this paper as well. Estimation results give suggestive evidence for the two vital insights we obtained in theoretical study.

Based on all analysis we have made in preceding sections, we provided one plausible answer for our research question raised in the first section and disentangled the puzzle of horizontal spillovers of FDI to some degree. Now we can come to a conclusion: just as every medicine has its side-effects, the presence of multinationals will generate some undesirable effects to domestic firms at first, however it will go to the good direction ultimately and help host countries with their productivity development.
### TABLE 1

First Step estimation results with G(t), G(t+1) and V(t+1)/V(t) as explanatory variables.

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Standard errors in parentheses  
*** p<0.01, ** p<0.05, * p<0.1

Note: This table reports the estimation results of Equation (7). Dependent variable is learning investment I(t). Time dummy is only included in the last two columns.
TABLE 2

First Step estimation results with G(t), G(t+1), V(t+1) and V(t) as explanatory variables.

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<td>(0.00384)</td>
<td>(0.00316)</td>
<td>(0.00367)</td>
<td>(0.00307)</td>
</tr>
<tr>
<td>LM Test</td>
<td>RE</td>
<td>RE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hausman Test</td>
<td>FE</td>
<td>FE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>333</td>
<td>333</td>
<td>333</td>
<td>333</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.196</td>
<td>0.482</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of sector</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: This table reports the estimation results of Equation (8). Time dummy is only included in the last two columns.
Table 3
Second step estimation results.

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>ΔlnTFP based on d = 6%</th>
<th>ΔlnTFP based on d = 7%</th>
<th>ΔlnTFP based on d = 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Random</td>
<td>Fixed</td>
<td>Random</td>
<td>Fixed</td>
</tr>
<tr>
<td>lnV(t)</td>
<td>0.0384**</td>
<td>0.0495**</td>
<td>0.0409**</td>
</tr>
<tr>
<td></td>
<td>(0.0171)</td>
<td>(0.0196)</td>
<td>(0.0174)</td>
</tr>
<tr>
<td>lnV(t-1)</td>
<td>-0.0402**</td>
<td>-0.0316</td>
<td>-0.0427**</td>
</tr>
<tr>
<td></td>
<td>(0.0169)</td>
<td>(0.0199)</td>
<td>(0.0172)</td>
</tr>
<tr>
<td>G(t-1)</td>
<td>0.0427</td>
<td>0.210**</td>
<td>0.0410</td>
</tr>
<tr>
<td></td>
<td>(0.0379)</td>
<td>(0.102)</td>
<td>(0.0380)</td>
</tr>
<tr>
<td>I(t)</td>
<td>-1.954***</td>
<td>-2.424***</td>
<td>-1.990***</td>
</tr>
<tr>
<td></td>
<td>(0.666)</td>
<td>(0.746)</td>
<td>(0.676)</td>
</tr>
<tr>
<td>I(t-1)</td>
<td>1.497**</td>
<td>1.141</td>
<td>1.537**</td>
</tr>
<tr>
<td></td>
<td>(0.687)</td>
<td>(0.757)</td>
<td>(0.699)</td>
</tr>
<tr>
<td>Year Dummy</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0973***</td>
<td>0.112**</td>
<td>0.0991***</td>
</tr>
<tr>
<td></td>
<td>(0.0178)</td>
<td>(0.0495)</td>
<td>(0.0179)</td>
</tr>
<tr>
<td>LM Test</td>
<td>RE</td>
<td>RE</td>
<td>RE</td>
</tr>
<tr>
<td>Hausman Test</td>
<td>RE</td>
<td>FE</td>
<td>RE</td>
</tr>
<tr>
<td>Observations</td>
<td>333</td>
<td>333</td>
<td>333</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.512</td>
<td>0.511</td>
<td>0.500</td>
</tr>
<tr>
<td>Number of sector</td>
<td>37</td>
<td>37</td>
<td>37</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Dependent variable is first difference of log-form TFP calculated by different depreciation rates.
Since taking difference would strain the time span of the data set, observations reduce to 333.
Table 4

Robust test for first step estimation by using a new proxy for the presence of FDI

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Random effects</td>
<td>Fixed effects</td>
<td>Random effects</td>
<td>Fixed effects</td>
</tr>
<tr>
<td>G(t)</td>
<td>0.109***</td>
<td>0.111***</td>
<td>0.0602**</td>
<td>0.0628***</td>
</tr>
<tr>
<td></td>
<td>(0.0224)</td>
<td>(0.0223)</td>
<td>(0.0238)</td>
<td>(0.0238)</td>
</tr>
<tr>
<td>G(t+1)</td>
<td>0.0891***</td>
<td>0.104***</td>
<td>0.0348</td>
<td>0.0431*</td>
</tr>
<tr>
<td></td>
<td>(0.0240)</td>
<td>(0.0252)</td>
<td>(0.0248)</td>
<td>(0.0252)</td>
</tr>
<tr>
<td>V(t+1)/V(t)</td>
<td>-0.00231</td>
<td>-0.00240</td>
<td>0.000187</td>
<td>0.000118*</td>
</tr>
<tr>
<td></td>
<td>(0.00151)</td>
<td>(0.00150)</td>
<td>(0.00127)</td>
<td>(0.00007)</td>
</tr>
<tr>
<td>Year Dummy</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0164***</td>
<td>0.0198***</td>
<td>0.0133***</td>
<td>0.0147***</td>
</tr>
<tr>
<td></td>
<td>(0.00404)</td>
<td>(0.00384)</td>
<td>(0.00378)</td>
<td>(0.00314)</td>
</tr>
<tr>
<td>LM Test</td>
<td>RE</td>
<td>RE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hausman Test</td>
<td>FE</td>
<td>FE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>333</td>
<td>333</td>
<td>333</td>
<td>333</td>
</tr>
<tr>
<td>R-squared</td>
<td></td>
<td>0.094</td>
<td></td>
<td>0.461</td>
</tr>
<tr>
<td>Number of sector</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is $I_t$. A new proxy for the presence of foreign affiliates – employment ratio is used in this regression.
Table 5
Robust test for second step estimation by using a new measurement of capital to calculate TFP

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Random effects</td>
<td>Fixed effects</td>
<td>Random effects</td>
<td>Fixed effects</td>
</tr>
<tr>
<td>lnV(t)</td>
<td>0.0715***</td>
<td>0.0610***</td>
<td>0.0336**</td>
<td>0.0410**</td>
</tr>
<tr>
<td></td>
<td>(0.0192)</td>
<td>(0.0215)</td>
<td>(0.0154)</td>
<td>(0.0176)</td>
</tr>
<tr>
<td>lnV(t-1)</td>
<td>-0.0696***</td>
<td>-0.0482**</td>
<td>-0.0348**</td>
<td>-0.0294</td>
</tr>
<tr>
<td></td>
<td>(0.0192)</td>
<td>(0.0217)</td>
<td>(0.0153)</td>
<td>(0.0179)</td>
</tr>
<tr>
<td>G(t-1)</td>
<td>0.112***</td>
<td>0.294***</td>
<td>0.0502</td>
<td>0.231**</td>
</tr>
<tr>
<td></td>
<td>(0.0387)</td>
<td>(0.105)</td>
<td>(0.0372)</td>
<td>(0.0919)</td>
</tr>
<tr>
<td>I(t)</td>
<td>-2.993***</td>
<td>-4.538***</td>
<td>-1.653***</td>
<td>-1.927***</td>
</tr>
<tr>
<td></td>
<td>(0.629)</td>
<td>(0.663)</td>
<td>(0.602)</td>
<td>(0.670)</td>
</tr>
<tr>
<td>I(t-1)</td>
<td>1.556**</td>
<td>0.508</td>
<td>1.202*</td>
<td>1.040</td>
</tr>
<tr>
<td></td>
<td>(0.642)</td>
<td>(0.686)</td>
<td>(0.621)</td>
<td>(0.679)</td>
</tr>
<tr>
<td>Year Dummy</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Constant</td>
<td>0.126***</td>
<td>0.144***</td>
<td>0.0888***</td>
<td>0.0789*</td>
</tr>
<tr>
<td></td>
<td>(0.0157)</td>
<td>(0.0551)</td>
<td>(0.0172)</td>
<td>(0.0445)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>RE</th>
<th>RE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hausman Test</td>
<td>RE</td>
<td>RE</td>
</tr>
<tr>
<td>Observations</td>
<td>333</td>
<td>333</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.241</td>
<td>0.559</td>
</tr>
<tr>
<td>Number of sector</td>
<td>37</td>
<td>37</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: TFP is estimated by Levinsohn-Petrin semiparametric method with a new measurement of capital stock. The first two columns show estimation results when time dummy is excluded from regression equation, while the last two columns are the case when time dummy is included.
References


Kugler, 2006. “Spillovers from foreign direct investment: Within or between industries?” Journal of Development Economics 80, 444-477


Todo, 2004. “Technology Adoption in Follower Countries: With or Without Local R&D Activities?” Economic and Social Research Institute Discussion Paper Series No.104


