Multinational firms, Spillovers, and Productivity Growth: An Evolutionary Model

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Revised Version, October 2006

Abstract

To face with foreign competition, domestic firms have to improve their competitive power by either innovating or imitating foreign technologies, depending on their existing level of technological competence. Accordingly, spillover effects emerge as learning activities succeed in increasing firm's productivity. This paper provides an evolutionary model of productivity spillovers from foreign multinational firms. In contrast to the existing theoretical literature, it put forward that spillovers are determined by the interaction between the channels by which they occur and the technological characteristics of the recipient host firms. Simulation results show that (a) relatively high/mid technological domestic firms are highly likely to benefit from spillovers through demonstration and/or competition effects, while, relatively low technological domestic firms gain a lot from other forms of spillovers such as worker mobility, and that (b) spillover benefits are higher via worker mobility than via demonstration effects.

Keywords: Multinational firms; Competition; Imitation; Worker mobility; Technological characteristics; Spillover effects

1. Introduction

The attitude towards foreign direct investment has considerably changed the last two decades as many governments around the globe have liberalized their FDI regulations since the early 1980's and are now actively providing generous investment incentives to attract inward FDI (UNCTAD, 2003). While the expected potential benefits include employment creation, capital formation and export promotion, the rationale for these policy interventions often stems from the expectation of FDI spillovers resulting in productivity enhancement of domestic firms (Dunning, 1992). MNCs are assumed to posses some ownership advantages -superior knowledge- which make them more efficient than domestic rivals (Hymer, 1960, 1968). Host country governments expect that at least some of this firm specific asset will be transferred to domestic firms, thus enabling them to improve their performance in terms of productivity, skills, or export performance (Meyer, 2003). Generally, spillovers are said to take place when the entry or presence of MNC affiliates leads to productivity or efficiency benefits in the host country's local firms and the MNCs are not able to internalize the full value of these benefits (Blomström and Kokko, 1998). Such spillovers may materialize through four main channels: demonstration-imitation, movement of domestic labors who have been trained or worked at MNCs affiliates, increase of competition, and forward/backward linkages. It is noteworthy that this last channel has no room in my work, since I focus only on studying the intra-industry spillovers.

A large literature has developed over the last two decades the concept of intra-industry spillovers. Too often, scholars offer a partial description of such spillovers, since each of them analyzes merely one kind of these effects. For example, in Kopecky and Koizumi (1977), Findlay (1978), and Das (1987) spillovers are determined by the degree of foreign presence alone (contagion-type spillovers). In Wang and Blomström (1992) and Perez (1998) spillovers are rather endogenously generated by the technological competition between foreign affiliates and domestic firms (competition-related spillovers), while in Kaufman (1997) and Fosfuri et al. (2001) spillovers are the outcome of the movement of domestic labors who have been previously trained or worked at MNCs affiliates.

Just as spillovers have not been analyzed at the theoretical level in a complete picture with respect to their diverse channels, so empirical studies are also focused on giving partial analyses of these effects. In fact, spillover effects are by and large measured by the share of foreign presence in the corresponding industry. Even if foreign presence seems to be an appropriate

*This paper has been presented at the EcoMod International Conference, Regional and Urban Modeling, June 1-3, Brussels. It is based on chapter 5 of my doctoral dissertation, written under the guidance of Philippe Gugler at Fribourg University, I thank him for his helpful comments and suggestions. I thank as well Hatem Ghorbel for his software assistance. All remaining errors are mine.

measure for spillover effects through demonstration, it cannot hold the whole information about competition effects (Kokko, 1996) and worker mobility. This is the reason why there are evidence contrasts in the scant empirical evidence available. Yudayeva et al. (2000), Castellani and Zanfei (2001), and Haskel et al. (2002) for example find positive evidence for the existence of spillover benefits from FDI for respectively, Russia, Italy, and UK. While, using the same measure of spillovers, Aitken and Harrison (1999) for Venezuelan firms and Djankov and Hoekman (2000) for Czech Republic firms report negative and insignificant spillovers, respectively.

Other possible reason for the apparently contradictory findings from the country studies is that local characteristics may influence the incidence of spillovers. In fact only high technological firms are likely to benefit from FDI spillovers, whereas locations characterized by low technological competence are not able to exploit the technological opportunities arising from foreign presence (Cantwell, 1989 and Wang and Blomström, 1992). Mody (1989) adds that relatively high technological firms are highly likely to benefit from spillovers through demonstration and/or competition effects, while small technological firms which are not in position to compete with foreign firms, gain a lot from other forms of spillovers such as worker mobility, since this channel provides a (technical, managerial, etc.. . .) assistance which can help domestic firms to better understand and implement the foreign technology. This shows that even low technological firms may experience some spillover benefits from FDI and that only firms with very low technological competence to a point that they are not capable of reaping profits via any of the spillover channels enter into a process of cumulative decline and eventually leave the market.

The model to be formulated here differs from existing ones with respect to two main points: firstly, it offers a more comprehensive picture of FDI intra-industry spillovers by distinguishing these effects according to their diverse channels. Secondly it hypotheses that the size and the extent of spillovers depend largely upon the interaction between the mechanisms by which they occur and the technological levels of domestic firms.

The rest of this paper is organized as follows. Section 2 studies the characteristics of the model. Section 3 presents the model. Section 4 analyzes the simulation results obtained, and section 5 discusses some policy implications of my analysis and concludes the paper.

2. FDI mechanisms, technological characteristics and host country's technological development

Before we pass to introduce the equations of the model, it is worth analyzing two main factors mediating the size and the extent of spillovers: spillover channels and local technological characteristics.

2.1. FDI and spillover channels

As previously noted, FDI intra-industry spillovers benefits are assumed to occur through three channels, viz. demonstration effects, competition effects, and worker mobility. Domestic firms may improve their productivity when the foreign firms after entering the market demonstrate their advanced technologies, which may afterwards adapt and imitate them. When the increase in competition that occurs as a result of foreign entry forces domestic firms to introduce new technology and/or work harder. And when domestic workers trained by or working in MNCs affiliates (denoted here by "MNCs labor") may decide to leave and join an existing or open up a new domestic firm, taking with them some or all of the firm specific knowledge of the multinational. In this latter case, foreign affiliates are unlikely to be mute spectators as their secrets are diffused to domestic competitors, in that they choose to pay "MNCs labor" a benefit level (called a non-wage compensation) in addition to the direct wage in order to prevent them from leaving the firm. Then, to gain the access of foreign technologies with personnel assistance, domestic firms shall pay "MNCs labor" a wage mark-up superior to the benefit level (Kaufmann, 1997).

Obviously, the importance of such FDI effects depends broadly upon the mechanism by which they occur, given that: on the one hand, firms differ in their technological competence and in turn they differ in their choice of the way to benefit from the presence of FDI. Then, the relevance of each spillovers mechanism, as we shall see in the following section, varies with technological characteristics of domestic firms, in that if technological accumulation is continuous in each domestic firm, raising its productivity or lowering its costs along a given line of technological development, then no firm would abandon its existing pattern of innovation and imitate the technological knowledge of foreign competitor (Cantwell, 1999 and Silverberg and Verspagen, 1994). On the other hand, the amount and nature of the technologies transferred from foreign to domestic firms depend largely upon the mechanism by which they are transmitted. That is spillovers via worker mobility for example are likely to be higher than through demonstration effects, since worker mobility can lead to substantial improvements in productivity throughout the local economy by transferring not only public technology (the so-called "the logy"), but also the tacit element ("the technique") that is unlikely to be transferred through informal contacts between firms[1], as stated by Nelson (1982) "*research and development scientists from rival firms give papers at meetings of professional societies. They meet together for lunch to exchange information on the evolving frontiers of the logy, while trying to avoid disclosing details of particular techniques their firms may have under development at the time*".

Thus, the assessment of the existence and the extent of spillover benefits for a given (firms, industries, countries) calls upon a detailed analysis of these effects according to their ways of occurrence. A large literature (theoretical and empirical) has developed over the last two decades the concept of intra-industry spillovers. Nonetheless, most of the studies that are available offered a partial description of FDI spillovers, since each of them focuses on analyzing only one kind of these effects. Two exceptions are Kokko (1996) and Meyer and Sinani (2002), who note that the absence of a significant and positive effect of foreign investment on the productivity level concluded by a great amount of studies can be explained by the fact that the variable "foreign presence", which has been, by and large, used as a measure of spillover effects from FDI, seems to be inappropriate to capture much of the competition and worker mobility effects. They suggest disentangling the effect of demonstration and worker mobility from that of competition by employing technology and competition control variables. Such modelling strategy is likely to describe more correctly the process of spilling-over and then identify with accuracy the nature and the size of the resultant effects. The model developed here is well suited for this purpose.

2.2. Local technological characteristics and spillovers

It is well known in the literature on FDI spillovers that absorptive capacity of domestic firms is, by and large, the most important determinant of spillovers. This concept encompasses the firm's ability to recognize valuable new knowledge, integrate it into the firm and use it productively. For domestic firms to utilize knowledge encountered through interaction with foreign investors, they have to make their own investment in R&D that allow for imitation and then productivity growth. Only firms possessing sufficient levels of absorptive capacity are likely to efficiently exploit spillovers (Wang and Blomström, 1992).

Besides imitation, domestic firm may improve its competitive power vis-à-vis its foreign rivals by learning within its existing line of technological development. Firm's ability to choose either to absorb foreign technology or to pursue independent lines of technological development, depends on its existing level of technological competence. Thus, domestic firms benefit from spillovers from FDI in accordance with their existing technological levels or their initial technological gaps. Two very different perspectives exist in the literature on this matter: on the one hand, it is argued, according to the advantages of backwardness hypothesis, that the wider the technological gap, the greater the opportunities for domestic firms to achieve higher level of efficiency by learning from FDI (Findlay, 1978). On the other hand, it is asserted that a wide technological gap impairs domestic firms ability to catch up with foreign competitors (Cantwell, 1989).

The model developed here relies on this second strand of analysis. It rests in fact on the hypothesis that effective learning activities are highly related to the existence of relatively small technological gaps. In other words, domestic firms with low technological level, are unlikely to experience positive spillovers, which in turn leads foreign firms to have no reason to import more and newer technologies from mother companies, since technology imports are costly. An extensive empirical literature has been done in line with this argument, by among others (Kokko at al. 1996, Glass and Saggi 1998, Girma et al. 1999, and Buckley et al. 2002).

Nonetheless, my model assumes as well that even low technological firms may experience some spillover benefits from FDI, in that they may gain a lot from personnel assistance drawn from the movement of "MNCs labor". Thus, this kind of firms has a great interest in turning its learning efforts to the recruitment of "MNCs labor" so as to get some assistance in imitating foreign technologies and then raising its productivity level. As Mody (1989) states, relatively high technological firms are highly likely to benefit from spillovers through demonstration and/or competition effects, while domestic firms with relatively moderate technological competence, which are not in position to compete fiercely with foreign firms, gain a lot from other forms of spillovers such as worker mobility, since this channel provides a (technical, managerial, etc.. . .) assistance which can help domestic firms to better understand and implement the foreign technology. Then, only firms with very low technological competence to a point that they are not capable of reaping profits via any of the spillover channels enter into a process of cumulative decline and eventually leave the market.

Given this assumption, FDI spillovers are determined by the interaction between the channels by which they occur and the technological characteristics of the recipient host firms. In fact, spillovers increase with the technological gap up to a certain critical level, beyond this point technological competence of domestic firms will be so low that they will generally not be able by no means to exploit efficiently the technological opportunities arising from foreign MNC presence. Obviously, diverse factors intervening in the determination of this critical level, viz. the capacity of domestic firms in attracting "MNCs labor" by giving them a mark-up superior to the benefit level, the level of complexity of foreign technologies, the appropriability regime, etc.

3. The model

Drawing extensively on the work of Perez (1998) in which he explains the process of FDI spillovers by means of a dynamic interaction between foreign and domestic firms at the technological level, we embed the question of spillovers into a larger one by allowing for different mechanisms by which domestic firms benefit from FDI. In fact, to protect its market share, domestic firm may choose to innovate or imitate foreign technologies according to its technological competence. Successful learning drives then domestic firms to improve their competitive power relative to their foreign rivals.

Accordingly, the model developed in what follows embodies the following properties:

(i) The size and extent of spillovers vary upon the mechanism by which they occur, which in turn depend on the level of technological capacity of domestic firms,

(ii) Besides technological conditions, domestic firm may acquire the foreign best practice technology via the recruitment of MNC workers according to its capacity in attracting MNCs labor by giving them a mark-up superior to the benefit level,

(iii) Firm's market share grows accordingly with its technological level relative to the other firms operating in the market,

(iv) Technology imports by foreign firms are inversely related to the existing technological gap and its capacity to protect its technological advantages from labor turnover,

(v) The dimension of market grows with the national income according to a "Keynesian" mechanism of demand formation.

3.1. The selection environment

The model developed here is of an industry in which a number (n) of firms produce a single homogeneous product. Each firm undertakes two activities, namely learning (via innovation and imitation) and production; labor is the only input in both activities.

The basic framework of the model is taken from Dosi and Fabiani (1994). Let dots stand for growth rates, f_i be the market share of firm i, E_i its absolute competitiveness, and $\bar{E}$ the average competitiveness on market. Then, the dynamics of the market share of firm i depends on its relative competitiveness as follows

$$\dot{f}_i\left(t,t+1\right)=a\left[\frac{E_i\left(t\right)}{\bar{E}\left(t\right)}-1\right]f_i\left(t\right), \tag{1}$$

with

$$\begin{aligned} f_i\left(t\right) &= \frac{Y_i\left(t\right)}{Y\left(t\right)}, && (2)\\ E_i\left(t\right) &= \frac{1}{p_i\left(t\right)}, && (3)\\ \bar{E}\left(t\right) &= \sum_i f_i\left(t\right)E_i\left(t\right), && (4)\end{aligned}$$

where p_i is the price charged by the i-th firm, Y_i its output (= income), and Y the total output.

This replicator dynamic (equation(1)) associated with market selection entails the coexistence of firms characterized by different levels of efficiency and different behavioral rules. The parameter a represents market selectiveness, in that firms whose behavior resulted in highly competitive power will grow (in terms of market share) and others will loose the race, eventually forcing them to leave the market. Firms consequently exit the industry when

$$f_i<f_{\min}. \tag{5}$$

Given the equations (1) and (2) and assuming the existence of two groups of firms - foreign and domestic - interacting with each other in the industry, the output dynamic of the domestic firm is

$$\dot{Y}_{iD}\left(t,t+1\right)=a\left[\frac{E_{iD}\left(t\right)}{\bar{E}\left(t\right)}-1\right]\frac{Y_{iD}(t)}{Y(t)}Y\left(t+1\right)+\frac{Y_{iD}(t)}{Y(t)}\dot{Y}\left(t,t+1\right), \tag{6}$$

While, the output dynamic of foreign firm is determined by its relative competitiveness with the addition of the flows of new foreign direct investment (FDI), measured by the additional investment available to employ new workers ($N_i^{FDI}(t)=\frac{FDI_i(t)}{(w_{iF}(t)+b_i(t))}$), where b, as we shall see later, refers to the non-wage compensation (benefits) foreign firm chooses in order to minimize the movement of its labor.

$$\begin{aligned}\dot{Y}_{i_F}\left(t,t+1\right) &= a\left[\frac{E_{i_F}\left(t\right)}{\bar{E}\left(t\right)}-1\right]\frac{Y_{i_F}(t)}{Y(t)}Y\left(t+1\right)+\frac{Y_{iF}(t)}{Y(t)}\dot{Y}(t,t+1)\\ &\quad +N_i^{FDI}(t+1)\pi_{iF}(t+1)p_{iF}\left(t+1\right), \qquad (7)\end{aligned}$$

where FDI is endogenously determined as follows

$$FDI_i\,(t+1) = \kappa_i Y_{i_F}(t). \tag{8}$$

with κ_i depends on the existing technological gap between foreign firm and domestic leader $(Gap_i^{'}(t) = \pi_{iF}(t)/\pi_{iD}^{*}(t))$ as

$$\kappa_i(t) = \exp(-Gap_i^{'}(t)). \tag{9}$$

Pricing is based on mark-up procedure

$$p_i\,(t) = \frac{w_i(t)}{\pi_i(t)}\,(1+\rho)\,, \tag{10}$$

with w is the nominal wage and, for the sake of simplicity, we take $(w_{iD} = w_{iF})$, ρ the mark-up, and π the labor productivity.

Workers employed in both production and learning (innovating and imitating activities) use all their wages received at time t to buy goods in the following period. Thus total demand which is equal to national income $Y(t)$ is given by

$$Y\,(t+1) = \sum_i w_i(t) N_i(t). \tag{11}$$

3.2. Innovating and imitating activities

To face with foreign competition, domestic firms have to improve their competitive power by either innovating or imitating foreign technologies. Then, spillovers emerge as learning activities succeed in increasing firm's productivity. However, performing any learning activity depends broadly upon the technological capacity of the corresponding firm - here, technological gap between domestic and foreign firms is taken as a proxy of technological capacity. As technological gap increases, spillovers increase up to a certain critical value and thereafter turn down. Then, the productivity of domestic firm determined by the number of domestic employees engaged in learning activities and its initial technological gap is given by

$$\frac{\dot{\pi}_{iD}\,(t,t+1)}{\pi_{iD}(t)} = \nu_1 + \lambda_0 \left[1 - \exp(-\mu_1 N_{iD}^{Learning}(t))\right] \frac{Gap_i(t)}{\exp(\lambda_1 Gap_i(t))}, \tag{12}$$

where technological gap is defined as the ratio between labor productivity in foreign leader and domestic firm: $Gap_i(t) = \pi_{iF}^{*}(t)/\pi_{iD}(t)$.

If the technological gap is too small, in that the productivity of domestic firm is greater than or equal to the productivity of the best practice technology of foreign firms, then domestic firm has no interest in imitation activity and vice versa.

$$N_{iD}^{Learning}(t) = \left\{ \begin{array}{ll} N_{iD}^{inn}(t) & \text{if } \pi_{iD}(t) \geqslant \pi_{iF}^{*}(t) \\ N_{iD}^{imi}(t) & \text{if } \pi_{iD}(t) < \pi_{iF}^{*}(t) \end{array} \right\}, \tag{13}$$

As previously noted, domestic firm may choose to acquire the foreign best practice technology via either the demonstration mechanism or the recruitment of "MNCs labor", or both[2].

$$N_{iD}^{imi}(t) = N_{iD}^{Dem}(t) + N_{iD}^{R}(t), \tag{14}$$

In the case of foreign firms, productivity growth depends upon the decision to import new technologies from mother company, which in turn depends on the existing technological gap between foreign firm and domestic leader $Gap^{'}$ and its capacity to protect its technological advantages from labor mobility b, and on the imitation of domestic best practice technology.

$$\frac{\dot{\pi}_{iF}(t,t+1)}{\pi_{iF}(t)} = \nu_2 + \lambda_2\left[1-\exp(-\mu_2 N_{iF}^{imi}(t))\right]\frac{1/Gap_i'(t)}{\exp[\lambda_3(1/Gap_i'(t))]} + \lambda_4\exp(-(Gap_i'(t)), \tag{15}$$

where b is determined as

$$b(t) = 1-\exp(-Gap_i'(t)). \tag{16}$$

3.3. Labor market dynamics

Firm's investment in learning (RD) is proportional to its previous-period output as

$$RD_i\,(t+1) = \eta Y_i\,(t)\,, \tag{17}$$

where N_i^P is the number of workers in productive activities, defined by

$$N_i^P(t) = \frac{Y_i(t)}{p_i\,(t)\,\pi_i(t)}. \tag{18}$$

Regarding domestic firms, if technological gap is too small, all their R&D resources are devoted to innovative activities

$$N_{iD}^{inn}(t) = \frac{RD_i(t)}{w_{iD}(t)}. \tag{19}$$

As concerns foreign firm, all R&D resources are devoted to imitative activities independently to technology transfer mechanisms

$$N_{iF}^{imi}(t) = \frac{RD_i(t)}{w_{iF}(t)}. \tag{20}$$

Imitative learning of domestic firm is proportional to the R&D resources devoted to both the imitation of the technology drawn from the demonstration process and recruitment of "MNCs labor" when some additional personnel assistance is required for a successful imitative draw.

$$N_{iD}^{imi}(t) = \frac{\gamma_{iD}RD_{iD}(t)}{w_{iD}(t)} + \frac{(1-\gamma_{iD})RD_{iD}(t)}{w_{iD}(t)(1+m_i(t))}, \tag{21}$$

with γ and $(1-\gamma)$ are respectively the fractions of firm's workforce engaged in the adaptation and the imitation of foreign technology acquired through demonstration effects (N^{Dem}) and by means of worker mobility (N^R). Domestic firm may choose to acquire the foreign best practice technology via either the demonstration mechanism or the recruitment of "MNCs labor", or both, according to its existing technological gap. γ is then a function of technological gap, that is, as gap increases, γ declines and domestic learning efforts are more devoted to the recruitment of "MNCs labor" to gain from personnel assistance.

$$\gamma_{iD}(t) = \exp(-Gap_i(t)), \tag{22}$$

In addition, the fraction of workers engaged in the imitation of the technology drawn from the recruitment of "MNCs labor" depends on ($\Gamma(t) = \frac{m(t)}{b(t)}$), the ratio between the mark-up (m) domestic firm attempts to pay to acquire "MNCs labor" and the benefit level foreign firm pay over wages to protect their technological advantages from labor turnover. Obviously, domestic firm attempts to recruit "MNCs labor" by choosing a mark-up superior to the benefit level.

$$N^R_{iD}(t) = \left\{ \begin{array}{ll} \frac{(1-\gamma_{iD})RD_{iD}(t)}{w_{iD}(t)(1+m_i(t))} & \text{if } \Gamma_{iD}(t) \geqslant 1 \\ 0 & \text{if } \Gamma_{iD}(t) < 1 \end{array} \right\}, \quad (23)$$

and

$$m_i(t) = \sigma_i Gap_i(t) \quad (24)$$

The wage dynamic is the same for both foreign and domestic firms and driven by labor productivity growth ($\dot{\Pi}$), consumer price changes ($\dot{P}$), and changes in the levels of employment ($\dot{N}$)

$$\dot{w}_i(t, t+1) = \upsilon_1 \dot{\Pi}(t-1, t) + \upsilon_2 \dot{P}(t-1, t) + \upsilon_3 \dot{N}(t-1, t), \quad (25)$$

where

$$\Pi = \sum_i f_i \pi_i, \quad (26)$$

$$P = \sum_i f_i p_i, \quad (27)$$

$$N = \sum_i (N_i^P + N_i^{Learning} + N_i^{FDI}). \quad (28)$$

4. Simulation results

In this section we report and analyze the results of simulation experiments using the model developed previously. These experiments are an exploration of the influence of learning activities and technological characteristics on productivity performance of domestic firms in terms of spillover benefits. Given the complexity of the dynamics defined by the equations of this model, we use simulation techniques to explore its outcome. The set of differential equations is solved using the language for simulation models named "the laboratory for simulation development"[3]. Each simulation counts 1500 iterations in order to show the tendency of the model to converge towards a lasting quasi-stationary state. Particular numerical initial values used in these simulation experiments are given in appendix.

4.1. On the role of local characteristics

The simulation results reported here are drawn on an industry of 13 domestic firms with diverse initial technological gaps and two foreign affiliates[4]. Three indicators are used to capture the effects of technological competence of domestic firms on spillovers, viz. the domestic firms' productivities, their market shares, and their technological gaps.

Figure 1 plots the relationship between initial technological gaps and the dynamic of domestic productivity. On the horizontal axis of the figure, the different values of initial technological gap are depicted, and on the vertical axis, there are bins for the observed values of domestic firm's productivity change. Two conclusions emerge from this figure. First, locations characterized by high, mid and even relatively low levels of technological development benefit from the FDI inflows in terms of productivity growth, while locations characterized by very low technological competence are not able to exploit the technological opportunities arising from foreign presence. Second, the extent of productivity spillovers grows with initial technological gaps up to a certain critical level (here, $Gap_{t=0} = 1.45$), thereafter spillovers wipe out as domestic firms couldn't face with foreign competition and then loose their market shares. The results obtained seem consistent with Perez's analysis.

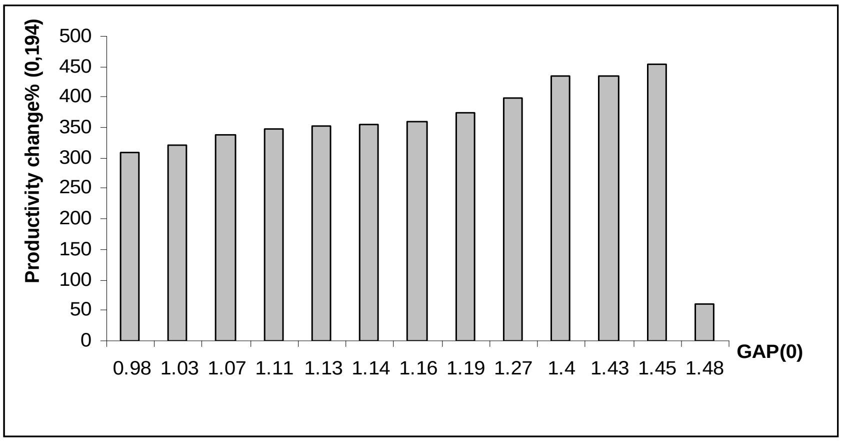

Figure 1: The percentage change in productivity over initial technological gaps.

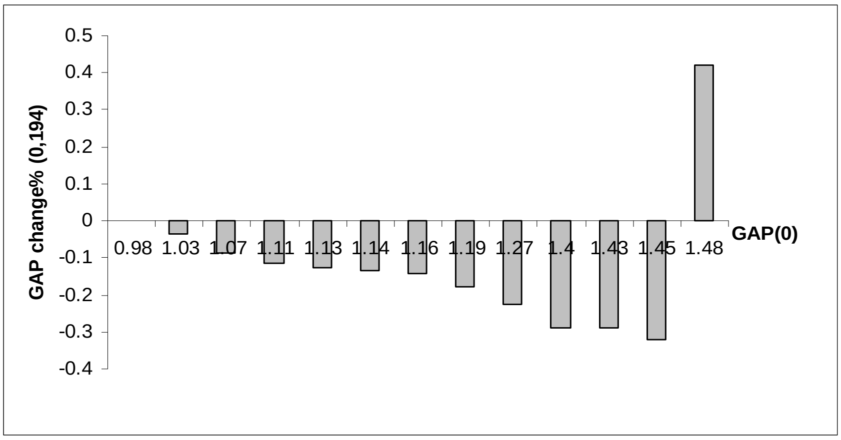

Figure 2: The percentage change in technological gaps over initial gaps.

Figure 2 plots the relationship between initial technological gaps and the dynamic of domestic technological gaps, using the same firms as in figure 1. Likewise, an increasing process of catching up by domestic firms emerges up to $Gap_{t=0}$ =1.45, which subsequently changes into a rapid process of falling behind.

Proposition 1 *the greater spillovers are, the wider the technological gap up to a certain critical level thereafter absorptive capacity of domestic firms declines.*

4.2. On the role of the interaction between technological characteristics and spillover channels

In what follows and for the sake of simplicity, we confine our sample to six firms in which we keep the same foreign firms and the four domestic firms considered as representative of the diverse technological categories of the industry. Figures 3, 4 and 5 resume the learning activities undertaken by these domestic firms to improve their competitive power vis-à-vis their foreign rivals, while figure 6 reports the effects of these activities on the catching up processes of domestic firms.

Figure 3 depicts the market shares of domestic and foreign firms over 1500 years. Firm D1, whose initial technological gap is less than 1, does not need to learn from foreign technologies to maintain its market share. Instead, this firm benefits from foreign presence via competition

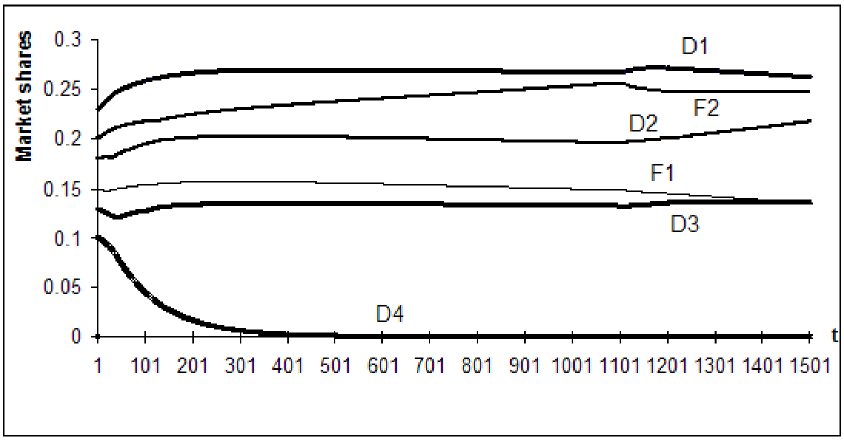

Figure 3: Market shares

effects as the competitive pressure generated by the presence of foreign firms induces it to use more efficiently its existing technology by learning within its existing line of technological development. Doing so, it maintains its competitive power and remains the leader of the industry. Firm D2, whose initial technological gap is slightly greater than one, adopts the foreign best technology as soon as it is no longer competitive to improve its technological competence. As shown in figure 4, this firm uses to a great extent the technique of demonstration to imitate foreign technology. Indeed, since this firm is not far behind the technological frontier of the industry, it manages to exploit fully the technological opportunities using merely demonstration effects. Firm D3, which belongs to the low level of technological development group with a relatively high initial gap, also manages to recover its market share by imitating foreign technologies. However, this firm is not able to benefit from foreign affiliates via demonstration effects alone, rather, as given by figure 5, it gains a lot from worker mobility as this channel provides a (technical, managerial, etc.. . .) assistance which can help it to better understand and implement the foreign technology. Firm D4 demonstrates the pitfalls of missing the boat by loosing its market share. This firm exerts a very low competitive pressure over foreign rivals. The market selection process drives it out of the market, eroding its profitability and, hence, its investment in learning.

Proposition 2 *High and mid technological firms are highly likely to benefit from spillovers through competition and demonstration effects, respectively. While, domestic firms with relatively low technological competence gain a lot from worker mobility.*

In what concerns figure 6, we have plotted the dynamic of technological gaps of the four domestic firms over their initial gaps. A first glance at this figure shows that firm D3 benefits the best from foreign presence with reference to catching up process, since worker mobility can lead to substantial improvements in its productivity by transferring not only public technology but also the tacit element that is unlikely to be transferred through informal contacts between firms. What clearly emerges from this figure is that the size and extent of spillover benefits depends upon the mechanism by which they are transmitted as spillovers from imitation seem to be higher than from innovation effects, and alike, spillovers via worker mobility are higher than via demonstration effects.

Proposition 3 *The size of spillover benefits depends upon the mechanism by which they are transmitted. Spillovers via worker mobility for example are found higher than through demonstration effects.*

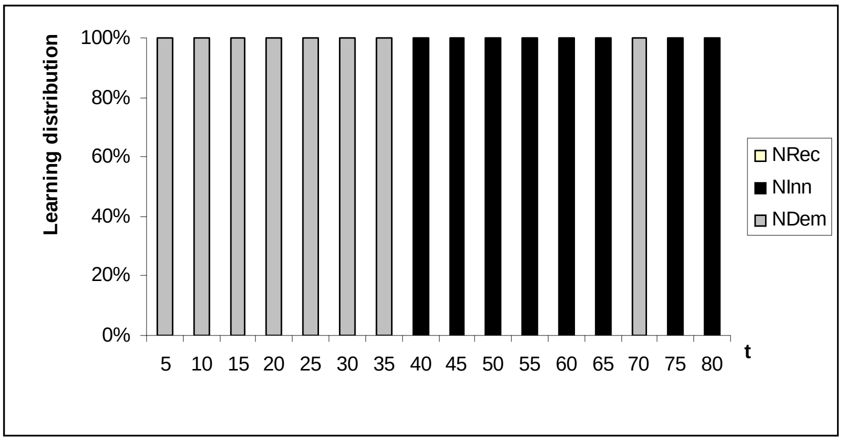

Figure 4: Learning distribution of D2.

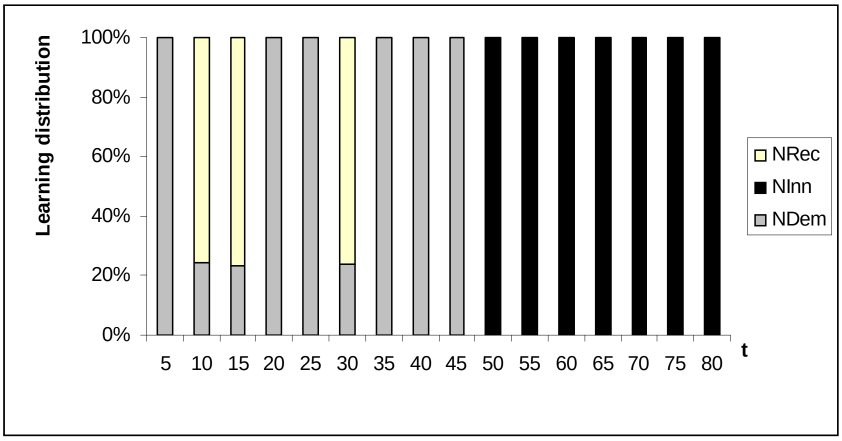

Figure 5: Learning distribution of D3.

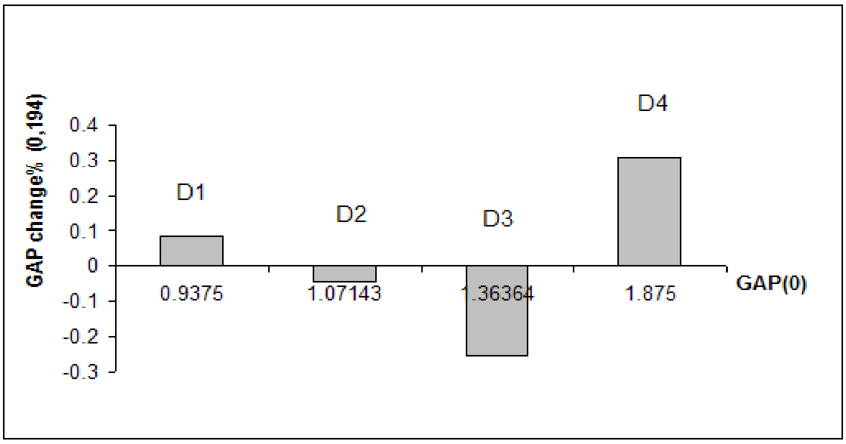

Figure 6: The percentage change in technological gaps over initial gaps.

5. Concluding remarks and policy implications

This paper suggests that the effects of foreign presence on the productivity development of domestic firms in terms of spillovers is likely to vary according to a number of indicators, namely, spillover channels and local technological characteristics. In this respect, spillovers are determined by the interaction between the channels by which they occur and the technological characteristics of the recipient host firms. The simulation results seem to confirm these hypotheses, in which a high/mid technological firm benefits a lot from either competition or demonstration effects, while a low technological firm manage to reap the benefit from foreign presence via the recruitment of MNCs' human capital, in that this channel provides a (technical, managerial, etc.. . .) assistance which can help domestic firms to imitate successfully foreign technology. These results also demonstrate that the size and extent of spillovers vary according to the mechanism by which they occur, spillovers via worker mobility for example are higher than through demonstration effects.

These theoretical findings give rise to several policy implications. Actions trying to attract foreign investors in order to promote the economic development are the optimal policy prescription. However, it is suggested that the positive effects of foreign entry might be enhanced by taking actions to support learning and investment in domestic firms, raising their ability and motivation to invest in absorbing foreign technologies and skills. Given that low technological firms use largely worker mobility mechanism to get foreign knowledge and since this channel is costly, government might, at least, partially finance their R&D efforts.

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Notes

[1]Wojnicka (2004) asserts that the mobility of labor is a source of tacit knowledge essential for innovativeness and competitiveness of local enterprises.

[2]As we will see in the following sections, This choice is determined by its existing technological gap.

[3]It is a software developed by Marco Valente as part of his PhD firstly at IIASA and then at Aalborg University (Valente, 1999).

[4]Particular numerical values used in this simulation experiment are given in the appendix.

Appendix

A summary of the parameters and the values employed in the runs analyzed in the paper is presented below.

$$
\begin{aligned}
&a && = 0.01\\
&\rho && = 0.1\\
&\lambda_1 && = 1.5\\
&\mu_1 \text{ (if } N_{iD}^{imi}(t-1) < 0) && = 0.2\\
&\mu_1 \text{ (if } N_{iD}^{imi}(t-1) > 0) && = 0.3\\
&w_{iD} = w_{iF} && = 0.16\\
&\nu_1 = \nu_2 && = 0\\
&\upsilon_1 = \upsilon_2 = \upsilon_3 && = 0.1
\end{aligned}
$$

When the industry has 6 firms: 2 foreign and 4 domestic firms

λ_{0i} (if $N^{imi}_{iD}(t-1) < 0$), $i = D_1 ... D_4$	$= 0.5$	$\eta_{F1} = \eta_{F2}$	$= 0.6$
λ_{0D1} (if $N^{imi}_{iD}(t-1) > 0$)	$= 0.62$	σ_{D1}	$= 0.04$
λ_{0D2} (if $N^{imi}_{iD}(t-1) > 0$)	$= 0.7$	σ_{D2}	$= 0.05$
λ_{0D3} (if $N^{imi}_{iD}(t-1) > 0$)	$= 0.77$	σ_{D3}	$= 0.07$
λ_{0D4} (if $N^{imi}_{iD}(t-1) > 0$)	$= 0.75$	σ_{D4}	$= 0.07$
η_{D1}	$= 0.9$	λ_2	$= 0.15$
η_{D2}	$= 0.92$	λ_3	$= 0.3$
η_{D3}	$= 0.95$	λ_4	$= 0.05$
η_{D4}	$= 1$	μ_2	$= 0.33$

π_{D1}	$= 0.8$	f_{D1}	$= 0.23$
π_{D2}	$= 0.7$	f_{D2}	$= 0.18$
π_{D3}	$= 0.55$	f_{D3}	$= 0.13$
π_{D4}	$= 0.4$	f_{D4}	$= 0.10$
π_{F1}	$= 0.6$	f_{F1}	$= 0.15$
π_{F2}	$= 0.75$	f_{F2}	$= 0.20$

When the industry has 15 firms: 2 foreign and 13 domestic firms

λ_{0i} (if $N^{imi}_{iD}(t-1) < 0$)	$= 0.601$	η_{D1}	$= 0.913$
λ_{0D1} (if $N^{imi}_{iD}(t-1) > 0$)	$= 0.711$	η_{D2}	$= 0.921$
λ_{0D2} (if $N^{imi}_{iD}(t-1) > 0$)	$= 0.721$	η_i, $i = D_3 ... D_8$	$= 0.94$
λ_{0D3} (if $N^{imi}_{iD}(t-1) > 0$)	$= 0.722$	η_i, $i = D_9 ... D_{11}$	$= 0.95$
λ_{0i} (if $N^{imi}_{iD}(t-1) > 0$), $i = D_4 ... D_8$	$= 0.723$	η_{D12}	$= 0.951$
λ_{0i} (if $N^{imi}_{iD}(t-1) > 0$), $i = D_9 ... D_{13}$	$= 0.73$	η_{D13}	$= 0.968$

$\eta_{F1} = \eta_{F2}$	$= 0.65$	$\sigma_{D8} = \sigma_{D9}$	$= 0.034$
σ_{D1}	$= 0.03$	$\sigma_{D10} = \sigma_{D11}$	$= 0.036$
$\sigma_{D2} = \sigma_{D3}$	$= 0.031$	$\sigma_{D12} = \sigma_{D13}$	$= 0.04$
σ_{D4}	$= 0.0317$	λ_2	$= 0.184$
σ_{D5}	$= 0.032$	λ_3	$=0.301$
$\sigma_{D6} = \sigma_{D7}$	$= 0.033$	λ_4	$= 0.03$

π_{D1}	$= 0.82$	π_{D9}	$= 0.63$	f_{D1}	$= 0.079$
π_{D2}	$= 0.78$	π_{D10}	$= 0.57$	f_{D2}	$= 0.076$
π_{D3}	$= 0.75$	π_{D11}	$= 0.56$	f_{D3}	$= 0.074$
π_{D4}	$= 0.72$	π_{12}	$= 0.55$	f_{D4}	$= 0.073$
π_{D5}	$= 0.71$	π_{13}	$= 0.54$	f_{D5}	$= 0.072$
π_{D6}	$= 0.7$	π_{F1}	$= 0.76$	f_{D6}	$= 0.071$
π_{D7}	$= 0.69$	π_{F2}	$= 0.8$	f_{D7}	$= 0.069$
π_{D8}	$= 0.67$	μ_2	$= 0.17$	f_{D8}	$= 0.068$

f_{D9}	$= 0.061$
f_{D10}	$= 0.055$
f_{D11}	$= 0.054$
f_{D12}	$= 0.053$
f_{D13}	$= 0.043$
f_{F1}	$= 0.075$
f_{F2}	$= 0.077$