Endogenous innovation and spillover: a new proximity-concentration trade-off*

preliminary and incomplete

Antoine VATAN†

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Abstract

This paper develops a duopoly model of trade and FDI with endogenous innovation and spillovers. Two different timings of the model allow to study the influence of strategic interactions on the proximity-concentration trade-off and on innovation. Contrary to most of the literature, a fall in trade cost may encourage FDI rather than export as observed in the 1990's and FDI may discourage innovation.

Keywords: innovation, spillover, oligopoly, proximity-concentration trade-off, strategic interaction.

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†Université Paris 1 Panthéon-Sorbonne. Centre d'économie de la Sorbonne, 106 bd. de l'Hôpital, 75013 Paris. CREST-LMA. 15 bd Gabriel Peri, 92245 Malakoff. antoine.vatan[arrowbase]ensae.fr

1 Introduction

Most of the literature on foreign direct investment (FDI) and spillovers has mainly focused on how the presence of FDI affects productivity of domestic firms or, at a more macro level, on economic growth of the host country. There are some strong evidences that inward FDI enhance R&D spillovers and productivity gains of the host country more than trade (see Hejazi and Safarian (1999)). This part of the literature mainly interests the developing countries. Attracting FDI has become an important policy element for developing countries to pursue growth. For instance, in the manufacturing sector, FDI is often seen as an amalgamation of capital, technology, and managerial skills. In this way, most of developing countries see FDI as a facilitation to technology transfert and a way to reduce the technology gap between developing contries and industrial countries. In that way, FDI is always supposed to enhance welfare of the host country.

However, there are also some strong evidences that multinational firms choose to make FDI where the productivity, education, skillness etc. are higher in order to benefit from some spillovers gains. This is the reverse way of spillover: it benefits to the foreign firm from the host country. Even if developing countries is a growing part of inward FDI, industrial countries remain the major part. It is well known that market size is a key determinant of FDI, but there can be some profitability of making FDI through technology transfer from host country (or domestic firms) to foreign entrants. So, in a reverse way, the foreign firm may improve its productivity by benefiting from costs reduction. Siotis (1999) shows that presence of spillovers increases profitability of FDI and may induce a firm to invest abroad, even in the absence of exporting cost. Hence there are incentive to invest where the productivity is higher even if it induces a thougher competition.

The aim of this paper is to introduce endogenous process innovation in a duopoly model of trade versus FDI.[1] The model assumes one firm in each country. The domestic firm exports to the foreign market. It can invest in process innovation by paying a convex

[1] The decision of a firm facing entry to a new market via export versus FDI is more likely to be analized in the oligopolistic setting. See the seminal papers of Horstmann and Markusen (1992) and Fosfuri and Motta (1999).

cost. The foreign entrant chooses either to export or to do FDI to the domestic market. In the latter case, foreign firm have to support a certain fixed cost in order to buy a new plant but it benefits at the same time from spillovers. The presence of endogenous innovation and spillovers provides a new proximity-concentration trade-off. Engaging in FDI reduces marginal cost in two ways, (1) by avoiding to pay transport costs and (2) by generating productivity gains from spillovers. Barac (2010) had already introduced spillovers in an oligopolistic model and find that FDI may be profitable even at zero trade cost but the incentive to make FDI (the so-called "tariff-jumping gain") is an increasing function of trade cost as the standard proximity-concentration trade-off prediction. In our model, thanks to endogenous innovation we provide an explanation of the well-known stylized fact of the 1990's where a trade liberalization led to a growth of FDI flows much higher than growth of trade which can be understood if tariff-jumping gain is a decreasing function of trade cost. Studying two timings of this models will allow to provide different predictions and then will highlight the role of strategic interactions. This paper contributes to showing the need of putting back strategic interactions into trade theory.

In the first timing, the domestic firm chooses its innovation level before the decision of its foreign competitor. This sequence of the game allows the host firm to set strategically its innovation level in order to block entry by FDI. That leads, in most of the case, to a suboptimal innovation level and non profitability of FDI. In most of the cases, a fall in trade cost encourages FDI, as in the standard proximity-concentration trade-off, and there is a case where a fall in trade cost induces a lower innovation level which is nefast for the consumer's surplus of the host country.

In the second timing, the foreign firm will choose between export and FDI to serve the domestic market before the innovation decision of the domestic firm. Anticipating the level of innovation of the host firm, the foreign competitor will choose FDI if spillovers are strong enough. This prediction maps with the empirical evidence. Since the innovation's level is a decreasing function of trade cost, a trade liberalization may favor FDI. At a given, and sufficiently high level of spillover, a fall in trade costs will increase the innovation level and then will improve the profitability of making FDI through marginal cost reduction induced by technology transfer.

In the section 2, we will present the general baselines of the model and give some prediction. In the section 3, we assume quadratic preferences in order to provide an illustration of this model and give some analytical results.

2 The general model

Assume a two country, home and foreign (respectively denoted by h and f), duopoly model with complete and perfect information. The model assumes one firm in each country. The domestic competitor exports to the foreign market. It can invest in process innovation (e) by paying a convex cost $F(e)$. The foreign one, chooses either to export or to do FDI to the domestic market. In the latter case, the foreign firm has to support a fixed cost f_D in order to buy a new plant but it benefits at the same time from spillover that reduces its marginal cost.

We denote by Π^s the total profit of the domestic firm when the foreign one chooses the strategy s, with $s = X$ if it exports and $s = M$ if it makes FDI. π_i is the profit of the domestic firm in the country $i = d, f$. τ is the transport cost, c is the relative marginal cost of the foreign firm, A is the relative size of the domestic market and δ is the strength of spillover assumed to be lower than one.

$$\Pi^X = \pi_d^X(\overset{+}{\tau}, \overset{+}{c}, \overset{+}{e}, \overset{+}{A}) + \pi_f^X(\overset{-}{\tau}, \overset{+}{c}, \overset{+}{e}) - F(e)$$

$$\Pi^M = \pi_d^M(\overset{-}{\delta}, \overset{+}{c}, \overset{+}{e}, \overset{+}{A}) + \pi_f^M(\overset{-}{\delta}, \overset{-}{\tau}, \overset{+}{c}, \overset{+}{e}) - F(e)$$

The spillover effect implies that $\frac{\partial \pi_d^X}{\partial e} \geq \frac{\partial \pi_d^M}{\partial e}$ and $\frac{\partial \pi_f^X}{\partial e} \geq \frac{\partial \pi_f^M}{\partial e}$ because part of the benefit of the innovation is transferred to the foreign competitor in case of FDI. It is straightforward that for every $e \geq 0$, $\Pi^X(e) \geq \Pi^M(e)$. These two inequalities leads to a lower optimal innovation level in case of FDI than in case of export. If we denote by e^s the innovation level chosen in the case of strategy s, it is straightforward that the first order conditions yield:[2]

$$e^X \geq e^M$$

and both of these optimal levels are negative functions of τ. Since a trade liberalization implies a higher quantity sold by the domestic firm, a reduction of τ provides her incentives to reduce her marginal cost.

Now, let's define $(\Pi^*)^s$ the total profit of the foreign firm when it chooses the strategy s. $(\pi^*)_i$ is the profit of foreign firm in country i.

$$(\Pi^*)^X = (\pi^*)^X_d(\overset{-}{\tau}, \overset{-}{c}, \overset{-}{e}, \overset{+}{A}) + (\pi^*)^X_f(\overset{+}{\tau}, \overset{-}{c}, \overset{-}{e})$$

$$(\Pi^*)^M = (\pi^*)^M_d(\overset{+}{\delta}, \overset{-}{c}, \overset{?}{e}, \overset{+}{A}) + (\pi^*)^M_f(\overset{+}{\delta}, \overset{+}{\tau}, \overset{-}{c}, \overset{?}{e}) - f_D$$

The effect of e on $(\Pi^*)^M$ may be positive or not. But, in case of FDI, a raise of e will at least affects less negatively the foreign firm profit than in case of export due to technology transfer. For a sufficiently high δ, the effect of e on $(\Pi^*)^M$ may even be positive. The only restrictions that we need is:

$$\begin{aligned} \forall e \geq 0, \quad & \frac{\partial(\Pi^*)^X}{\partial e} \leq \frac{\partial(\Pi^*)^M}{\partial e} \\ \text{for } e = 0, \quad & (\Pi^*)^X > (\Pi^*)^M \end{aligned}$$

Under these two conditions, there exist a unique threshold e^* above which the foreign firm has incentive to make FDI and under which it has incentive to export.[3] If we define the

[2]Proof: the optima levels e^X and e^M satisfy the two following f.o.c. respectively:

$$\begin{aligned} \frac{\partial \Pi^X}{\partial e} = 0 \Leftrightarrow \frac{\partial \pi^X_d}{\partial e} + \frac{\partial \pi^X_f}{\partial e} = F'(e) \\ \frac{\partial \Pi^M}{\partial e} = 0 \Leftrightarrow \frac{\partial \pi^M_d}{\partial e} + \frac{\partial \pi^M_f}{\partial e} = F'(e) \end{aligned}$$

With $\frac{\partial \pi^X_d}{\partial e} \geq \frac{\partial \pi^M_d}{\partial e}$ and $\frac{\partial \pi^X_f}{\partial e} \geq \frac{\partial \pi^M_f}{\partial e}$ and convex $F(e)$, it is straightforward that $e^X > e^M$.

[3]If $(\Pi^*)^X(0) \leq (\Pi^*)^M(0)$, there exist no $e^* > 0$. Note that here, we exclude negative profits, so we consider the cases where both $(\Pi^*)^X(e^*)$ and $(\Pi^*)^M(e^*)$ are positive

tariff-jumping gain ($\phi(\delta, \tau, c, e, A)$) as the difference between profits from making FDI and profits from exporting (as in Neary (2002)), e^* is the threshold above which $\phi(.)$ becomes positive. It is straightforward that e^* is a negative function of τ, a negative function of c and A and the lower the threshold e^*, the more likely FDI occurs. That is in line with stylized facts that tell us that FDI is more likely to occur in a large market and concern highly productive firms.

In the following two subsections, we will consider two timings. First we will asume that the domestic firm moves first, that is to say that the domestic firm chooses its innovation level anticipating its competitor's strategy. We will see that in most cases this leads to a suboptimal level of innovation and trade liberalization tends to increase innovation level and to discourage FDI. Second, we will assume that the foreign firm moves first. In this second case, the level of innovation is chosen observing the strategy of the foreign firm, so it will be always chosen at the optimal level. This second case provides an explanation for a positive correlation between trade liberalisation and the rise in FDI.

2.1 First timing: the domestic firm moves first

In this first subsection, we will consider the following timing:

i) The domestic firm chooses its innovation level

ii) The foreign firm chooses its strategy (X or M)

iii) Cournot competition on both markets determines prices and outputs

This timing allows the domestic firm to set an innovation level strategically in order to keep the foreign firm away. If the innovation level is higher than e^*, then the foreign firm will make FDI, that can lead to a lower profit of the domestic firm than if it chooses an innovation level that does not permit the foreign competitor to make FDI.
Depending on the relative marginal cost, trade cost and the market access, there are three cases in the level of the thresholds of interest:

i) $e^* > e^X$

ii) $e^X \geq e^* > e^M$

iii) $e^* \leq e^M$

In case (i), FDI does not represent a threat for the domestic firm. As we saw, $e^X \geq e^M$, it leads to:

$$\forall e \geq 0, \quad \Pi^X(e^X) \geq \Pi^X(e)$$

Hence, the chosen level of innovation is e^X, FDI never occurs and a fall in trade cost leads to higher innovation.

In the case (ii), FDI represents a threat. Since in this interval:[4]

$$\forall e \in [e^M; e^X], \quad \Pi^X(e) > \Pi^M(e^M)$$

the domestic firm will choose $e = e^* - \epsilon$, $\epsilon \to 0^+$ (see figure 3 in appendix). So, in this case, FDI never occurs also, but the level of innovation is strategically chosen at a suboptimal level. Since $\frac{\partial e^*}{\partial \tau} < 0$, a fall in trade costs increases the incentive to innovate. Overall, for $e^* > e^M$, a fall in trade cost implies a higher innovation level and never permits FDI.

Finally, in the third case (iii), there are two possibilities:
If $\Pi^X(e^*) > \Pi^M(e^M)$, the domestic firm has an incentive to block the entry by FDI and will choose $e = e^* - \epsilon$, $\epsilon \to 0^+$ (see figure 2 in appendix).
If $\Pi^X(e^*) \leq \Pi^M(e^M)$, FDI may occur - and this is the only case in this timing - because for all $e < e^*$, the profit of domestic firm is lower than $\Pi^M(e^M)$ (see figure 1 in appendix). Hence in this case, the domestic firm will choose the optimal level of innovation e^M. In this model, FDI occurs only for sufficiently low values of e^* that require big market size, low marginal cost (before reduction by spillover) of foreign firm. FDI is also facilitated by high omptimal levels of innovation e^M and e^X. All these considerations are in line with several empirical studies that show that FDI only occur in the sector where innovation is high. Another prediction of the model tells us that FDI is more likely to occur in

[4]Proof:

$$\Pi^X(e^M) > \Pi^M(e^M) \text{ and } \forall e \in [e^M; e^X], \frac{\partial \Pi^X}{\partial e} > 0 \text{ and } \frac{\partial \Pi^M}{\partial e} < 0$$

sectors where spillovers are high. An empirical way to explore this prediction would be to compare the sectors where intellectual property rights are high/low. The model predicts that intellectual property rights discourage FDI in two ways: obviously because it reduces the spillover's degree but also because it blocks entry and by making so, it enhance the strength of strategic interactions.

2.2 Second timing: foreign firm moves first

In this section, we will consider the following timing:

i) The foreign firm chooses its strategy (X or M)

ii) The domestic firm chooses its innovation level

iii) Cournot competition on both markets determines prices and outputs

Here, the domestic firm chooses its innovation level after observing the strategy of the foreign entrant. In a context of complete information and rational expectations, we find the foreign firm's strategy by backward induction. Knowing the spillover degree, the foreign firm anticipates both levels e^X and e^M. Given the properties of the thresholds, we know that a fall in trade costs will increase both e^X and e^M.[5] Hence, at a given spillover degree a fall in trade costs will decrease the marginal cost of the foreign firm if it makes FDI because innovation will be higher. We will see later that it is possible to find a threshold of δ above which a fall in trade costs may encourage FDI.
As in Barac (2010), due to spillovers, the tariff jumping-gain may be positive everywhere (even at $\tau = 0$) but here, thanks to endogenous innovation, the tariff-jumping may be a negative function of trade costs. For a sufficiently high level of spillover, a trade liberalization encourages innovation and then can enhance the tariff-jumping gain by rising more rapidely $(\Pi^*)^M(e^M)$ than $(\Pi^*)^X(e^X)$. This context may provide a plausible explanation of the stylzed facts observed in the 1990's.

[5] We also know that e^X will increase more rapidly than e^M.

3 quadratic preferences: an illustration

In this section we use a standard Cournot-oligopolistic framework with quadratic preferences in order to provide some analytical results.

First of all let's define some notations of the production's side. The offered quantity by two firms on two markets are defined as follow:

		Market	
		Home	Foreign
firm	Home	x_s	x_s^*
	Foreign	y_s	y_s^*

We assume that in the domestic country, total consumed quantity is $Q_d^s = x_s + y_s$ and in the foreign country $Q_f^s = x_s^* + y_s^*$ and $s = X, M$ is the strategy choosen by the foreign firm.

Before innovation, firm $i = h, f$ has a marginal cost c_i. The domestic firm may invest in cost reducing innovation $c_h - e$ by paying a quadratic cost $(\gamma/2)e^2$. If the foreign firm serves the domestic market through FDI, it has to support a fixed cost f_D in order to buy a new plant. At the same time, it benefits from spillovers which are expressed as in d'Aspremont Jaquemin (1988): $c_f - \delta e$ with $\delta \in]0; 1[$ the strength of spillover. Without loss of generality, we assume that both firms may export at no fixed cost and at a transport cost τ.

The utility of the representative consumer is assumed to be the same in both countries:

$$U(Q, z) = aQ - \frac{1}{2}Q^2 + z$$

Where z is the consumption of the numeraire and Q the consumption of the good sold in oligopolistic competition. Parameter a is the consumers' maximum willingness to pay for the product which is assumed to be the same in both countries. Willingness to pay can be interpreted as the market size and since the effect of this parameter is well known we assume that it is the same in both countries.[6] The consumer then solves the utility

[6] Bigger market favors FDI

maximisation problem. The first order condition yields the inverse demand functions linear in Q. The products are assumed to be perfect substitutes, so the inverse demand functions are the same for both firms:

$$p(Q_d) = a - Q_d \quad \text{in the domestic country}$$
$$p(Q_f) = a - Q_f \quad \text{in the foreign country}$$

3.1 first timing

We solve the game by backward induction. Let's start by defining the sold quantities and profits of both firms under both strategies of the foreign firm.

If the foreign firm chooses to export, then profits are defined as follow:

$$\Pi^X = p(Q_d)x_X + (p(Q_f) - \tau)x_X^* - (c_h - e)(x_X + x_X^*) - \gamma/2e^2$$
$$(\Pi^*)^X = (p(Q_d) - \tau)y_X + p(Q_f)y_X^* - c_f(y_X + y_X^*)$$

And if FDI is the chosen strategy:

$$\Pi^M = p(Q_d)x_M + (p(Q_f) - \tau)x_M^* - (c_h - e)(x_M + x_M^*) - \gamma/2e^2$$
$$(\Pi^*)^M = p(Q_d)y_M + p(Q_f)y_M^* - (c_f - \delta e)(y_M + y_M^*) - f_D$$

Solving the first order conditions in a Cournot game yields to the following quantities:[7]

$$x_X = \frac{a - 2(c_h - e) + c_f + \tau}{3} \qquad x_X^* = \frac{a - 2(c_h - e) + c_f - 2\tau}{3}$$
$$y_X^* = \frac{a - 2c_f + (c_h - e) + \tau}{3} \qquad y_X = \frac{a - 2c_f + (c_h - e) - 2\tau}{3}$$

$$x_M = \frac{a - 2c_h + c_f + (2 - \delta)e}{3} \qquad x_M^* = \frac{a - 2c_h + c_f - 2\tau + (2 - \delta)e}{3}$$
$$y_M^* = \frac{a - 2c_f + c_h + \tau + (2\delta - 1)e}{3} \qquad y_M = \frac{a - 2c_f + c_h + (2\delta - 1)e}{3}$$

[7]In our model we exclude any corner solution *i.e.* we suppose that the second order condition is satisfied: $\frac{\partial^2 \Pi^M}{\partial e^2} < 0 \Leftrightarrow \gamma > \frac{4}{9}(2 - \delta)^2$. If this condition holds for $\delta = 0$, then it always holds. The true condition is: $\gamma > \frac{16}{9}$.

In this framework, it is easy to prove that profits of the firms take the following reduced form:

$$\Pi^X = (x_X)^2 + (x_X^*)^2 - \frac{\gamma}{2}e^2 \qquad \Pi^M = (x_M)^2 + (x_M^*)^2 - \frac{\gamma}{2}e^2$$
$$(\Pi^*)^X = (y_X)^2 + (y_X^*)^2 \qquad (\Pi^*)^M = (y_M)^2 + (y_M^*)^2 - f_D$$

Given this reduced form, the first order conditions w.r.t. the innovation level are straigthforward:

$$\frac{\partial \Pi^X}{\partial e} = 0 \Leftrightarrow e^X = \frac{2(2a - 4c_h + 2c_f - t)}{4.5\gamma - 8}$$
$$\frac{\partial \Pi^M}{\partial e} = 0 \Leftrightarrow e^M = \frac{2(2-\delta)(a - 2c_h + c_f - t)}{4.5\gamma - 2(2-\delta)^2}$$

Note that both optimal levels are negative functions of τ: a trade liberalization raises the total quantity sold by the domestic firm in both cases and then provides incentives to reduce her marginal cost. e^M is a negative function of the spillover's degree since it represents the technology transfer. Hence, for $\delta > 0$, marginal cost of the foreign competitor depends negatively on the innovation level.

Let's define the tariff-jumping gain as the difference between the profit of the foreign firm when it chooses the strategy M and its profit when it chooses the strategy X:

$$\phi = (\Pi^*)^M - (\Pi^*)^X$$

It is easy to prove that for positive quantities, there exist a unique threshold of innovation e^* above which ϕ is positive and below which ϕ is negative. So, if $e > e^*$, foreign firm chooses to make FDI and exports else.

Proposition 1 *In the first timing of the model:*

i) There exist a unique threshold e^* that respects interior solution

ii) FDI occurs only if $\Pi^M(e^M) > \Pi^X(e^*)$ which the case only for very low f_D, sufficiently large δ and a very productive foreign firm *iii) In all the cases of this timing, a fall in trade cost discourage FDI*

In this timing, the domestic firm has an incentive to under-invest in order to block entry by FDI, but if e^* is very low, which is true for sufficiently low levels of the fixed cost f_D and, at a given market size, for a very productive foreign firm. That is in line whith many empirical studies that show that only the most productive firms engage in FDI. Hence, FDI occurs only when e^* is sufficiently lower than e^M. Both of these levels are decreasing functions of τ, but in the present framework:

$$\frac{\partial e^*}{\partial \tau} < \frac{\partial e^M}{\partial \tau} < 0$$

Given that Π^X grows faster with e than Π^M for $e < e^M$, there are some cases where a fall in trade costs may discourage investment which is the case under the three following conditions:

$$\Pi^X(e^M(\tau_1)) > \Pi^X(e^*(\tau_1))$$
$$\Pi^X(e^*(\tau_1 - \Delta)) > \Pi^M(e^M(\tau_1 - \Delta))$$
$$e^M(\tau_1) > e^*(\tau_1 - \Delta)$$

With τ_1 the initial level of trade costs and $\Delta \leq \tau_1$ the magnitude of trade liberalization. In this case, a fall in trade cost raises e^* more rapidly than e^M. Then $\Pi^X(e^*)$ raises more than $\Pi^M(e^M)$, that gives an incentive to the domestic firm to block entry by FDI. Hence a trade liberalization discourages FDI, that is true in all the cases of the first timing, but in the precise case above, it can also discourage innovation. Here, a fall of trade costs will unambigously decrease the domestic consumer's surplus. Since the innovation level is lower, the quantities sold by the domestic firm are lower and the quantities sold by the foreign firm are even lower. That is the case for two reasons: it cannot make FDI, hence does not benefit from spillovers and has to pay τ (but if the trade liberalization leads to $\tau = 0$). In all the other cases, trade liberalization raises unambigously the domestic consumer's surplus.

3.2 second timing

Now, we consider the reciprocal case where the foreign firm moves first. Domestic firm chooses its innovation level observing the strategy of it foreign competitor, hence the level of innovation will be either e^M or e^X. Because the domestic firm moves in second, it is no more able to block entry by FDI.
So the tariff-jumping gain can be define as follow:

$$\phi = (\Pi^*)^M(e^M) - (\Pi^*)^X(e^X)$$
$$\phi > 0 \Leftrightarrow f_D < \underbrace{(y_M)^2 + (y_M^*)^2 - (y_X)^2 - (y_X^*)^2}_{>0, \forall e^X \geq e^M \text{ and } \delta \in]0;1[}$$

The FDI strategy will be choosen if and only if $\phi > 0$ which is feasible even for $\tau = 0$ as in Barac (2010) if δ is sufficiently high and for a sufficiently low fixed cost f_D. This result suggests that FDI only occurs in sectors or countries where the degree of spillover is sufficiently high. If we make the reasonable assumption that intellectual property rights (IPR) decrease spillover effect, this result is consistent with the study of Glass and Saggi (2002) that shows that IPR provides desincentives for FDI.

So, FDI may occur even at zero trade costs, but it is not sufficient in order to map with empirical evidences of the 1990's where a fall in trade costs did not discourage FDI. In order to match with this evidence we have to find the conditions under which the tariff-jumping gain is a decreasing function of trade cost. That is satisfied if the RHS of the previous inequality is itself a decreasing function of τ. Differentiating this expression with respect to τ gives a unique threshold δ^* above which $\frac{\partial \phi}{\partial \tau} < 0$. This threshold δ^* is itself a decreasing function of τ, that is to say that the lower the trade cost, the higher must be the spillover's degree in order to provide theoretical explanation of the empirical evidence of the 1990's.

Proposition 2 *In the second timing of the model there exist a unique threshold δ^* above which the tariff-jumping gain is a decreasing function of τ.*[8]

The intuition is quite simple: here, the domestic firm cannot set strategically its innovation

[8]Here, we have to set $\gamma \geq 2$ which is a bit more restrictive than the second order condition above. That is to say that the cost of innovation must be sufficiently convex.

in order to block entry by FDI. So, a trade liberalization will increase its innovation and for a sufficiently high degree of spillovers, the foreign firm has incentive to make FDI in order to capture a part of this high level of innovation. So, the model suggests that in sectors and countries where the technological transfer is high a trade liberalization may raise FDI.

This second timing may correspond to a model where there is no strategic interaction. If the domestic firm chooses its innovation level without considering its impact on prices and on the marginal cost of its competitor, then its innovation will be unambigously a decreasing function of τ and that is a necessary and sufficient condition for having the threshold δ^* above which the tariff-jumping gain is negatively correlated to trade cost. Hence, on this precise aspect, having no strategic interaction or having the foreign firm that moves first provides the same conclusion. The key feature here is that the domestic firm chooses its innovation level without to be able to block entry by FDI.

In this model we do not consider that foreign firm may benefit from some spillover effect if it exports. The model can be extented with a spillover degree that depends negatively on the distance between the two countries. So if the foreign firm makes FDI, it benefits from the higher technological transfer, because distance is zero with that strategy. This simple extension will provide the following prediction with the game played following the second timing: a fall in trade cost will encourage the firms located in the countries that are far from domestic market to make FDI and those located in nearest contries to export. In that context, a firm located in a close enough country will benefit more from spillover than in a remote country, so the incentive to pay the fixed cost f_D is lower in nearest country because the gain from spillover will be lower.

4 conclusion

This paper develops a simple duopoly model of trade and FDI and proposes to study the influence of strategic interactions on the proximity-concentration trade-off and on the level of innovation.

In absence of strategic interactions (which correspond to the second timing) and for the level of spillover sufficiently high, a fall in trade costs encourages FDI. A fall in trade costs raises the total quantity sold by domestic firm and then provides incentives to innovate. In that context, FDI is more likely to occur in the sectors where both innovation and spillovers degree are high. This prediction is at odds with the standard proximity-concentration trade-off and may provide reconciliation between theory and the experience of the 1990's. In this case, a trade liberalization unambigously increases welfare of the host country.

If there are strategic interactions, there is a unique threshold of innovation above which foreign firm engages in FDI. In most of the cases, the domestic firm anticipates foreign entry and chooses innovation level just below that threshold in order to block the entry since entry by FDI lowers its profit. Hence, the threat of entry by FDI reduces the incentive to innovate. FDI occurs only when the threshold is sufficiently low. A low threshold is favoured by high market access in domestic country, low fixed cost of engaging in FDI and low marginal cost of foreign firm (before reduction by spillover) that seems to be in line with stylized facts featuring that only the most productive firms engage in FDI. The model predicts a higher optimal level of innovation in export case than in FDI case. Hence, FDI reduces innovation either if it is effective or represents a threat. Summing up, with strategic interactions, a fall in trade costs encourages exports rather than FDI. Trade liberalization has ambigous effect here: in most of the cases, it provides incentive to innovate but it may also provide incentive to under-invest in order to block FDI, as the profit of the domestic firm raise more rapidly with a fall in trade costs if the choosen strategy by the foreign one is to export than if strategy is FDI.

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A Proof of proposition 1:

$$\forall\tau \geq 0, (\Pi^*)^M(e=0) < (\Pi^*)^X(e=0)$$
$$\forall e \geq 0, \frac{\partial(\Pi^*)^M}{\partial e} > \frac{\partial(\Pi^*)^M}{\partial e}$$

B Proof of proposition 2:

Let's set $A = a - 2c_f + c_h$:

$$\frac{\partial\phi}{\partial\tau} = (A - 4\tau - e^M) + \frac{\partial e^M}{\partial\tau}[(2\delta-1)(2A+\tau) + (2 - 8\delta + 8\delta^2)e^M] + \frac{\partial e^X}{\partial\tau}(2A - \tau - 2e^X)$$

$$\text{For } \delta = 0 \qquad e^X = e^M = e$$
$$\frac{\partial\phi}{\partial\tau} = (2A - 4\tau - e) - 2\frac{\partial e}{\partial\tau} > 0, \forall\tau \geq 0$$

$$\text{For } \delta = 1 \qquad \frac{\partial\phi}{\partial\tau} = \underbrace{2A(1 + 2\frac{\partial e^M}{\partial\tau})}_{<0,\forall\gamma\geq 2} + \underbrace{e^M(2\frac{\partial e^M}{\partial\tau} - 1)}_{<0} + \underbrace{2\tau(\frac{\partial e^M}{\partial\tau} - 2)}_{<0} + \underbrace{\frac{\partial e^X}{\partial\tau}(2A - \tau - 2e^X)}_{<0} < 0$$

$$\frac{\partial^2\phi}{\partial\tau\partial\delta} = 0 \Leftrightarrow$$
$$\frac{\partial e^M}{\partial\delta} - \frac{\partial^2 e^M}{\partial\tau\partial\delta}\left[(2\delta-1)(2A+t) + (2 - 8\delta + 8\delta^2)e^M\right] - \frac{\partial e^M}{\partial\tau}\left[\frac{\partial e^M}{\partial\delta}(2 - 8\delta + 8\delta^2)\right] =$$
$$\frac{\partial e^M}{\partial\tau}(4A + 2\tau + (16\delta - 8)e^M)$$

This equation admits either one or no solution for $0 \leq \delta \leq 1$. So, there is a unique $\delta^* \in]0;1[$ for which $\frac{\partial\phi}{\partial\tau} = 0$.

C graphics of first timing

The dotted lines represent Π^X and Π^M (Π^X always above Π^M) as functions of innovation level. The solid line depicts the effective profit of the domestic firm. The discontinuity appears in e^*. We set different values of f_D that provides different levels of e^*.

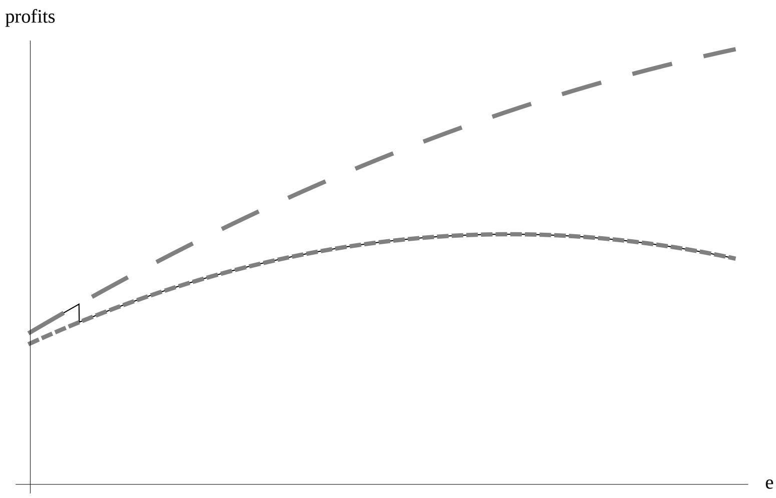

Figure 1: $f_D = 0.2$

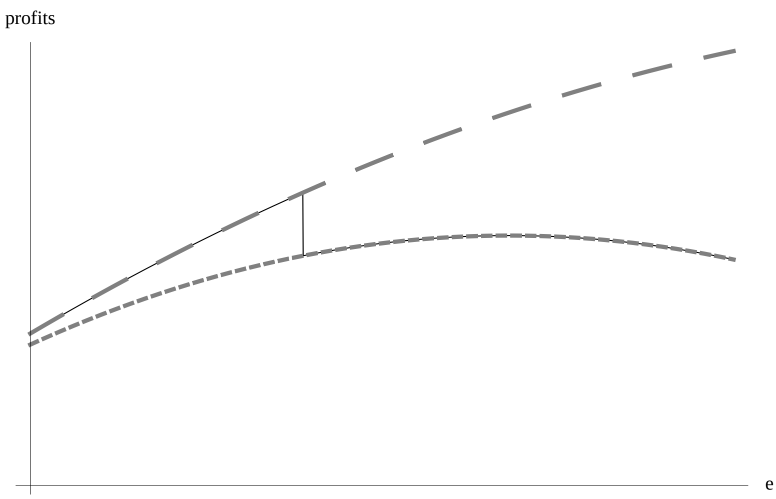

Figure 2: $f_D = 0.5$

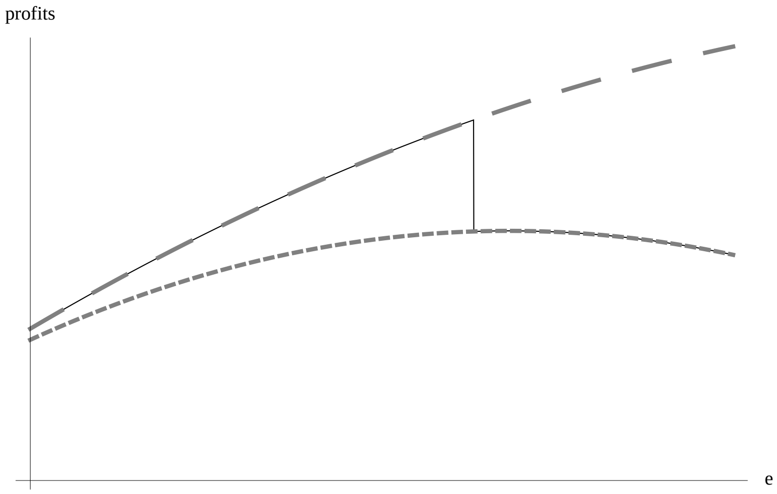

Figure 3: $f_D = 0.7$

D graphics of second timing

a	c_h	c_f	γ
6	3	4	2.2

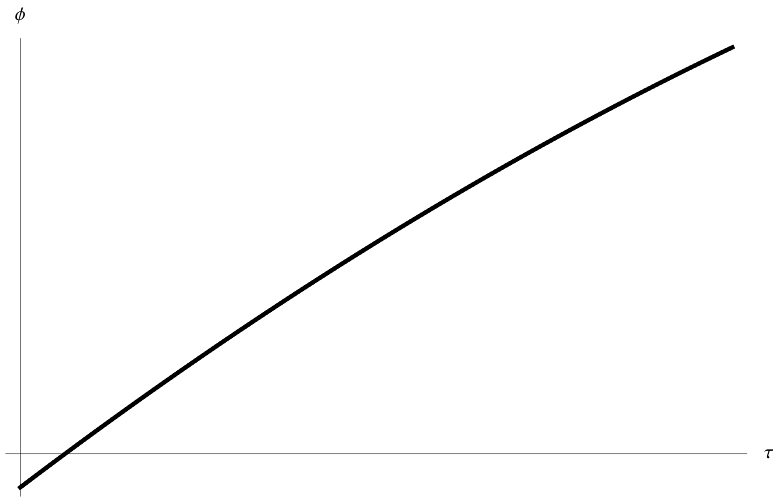

Figure 4: $\delta = 0.2$

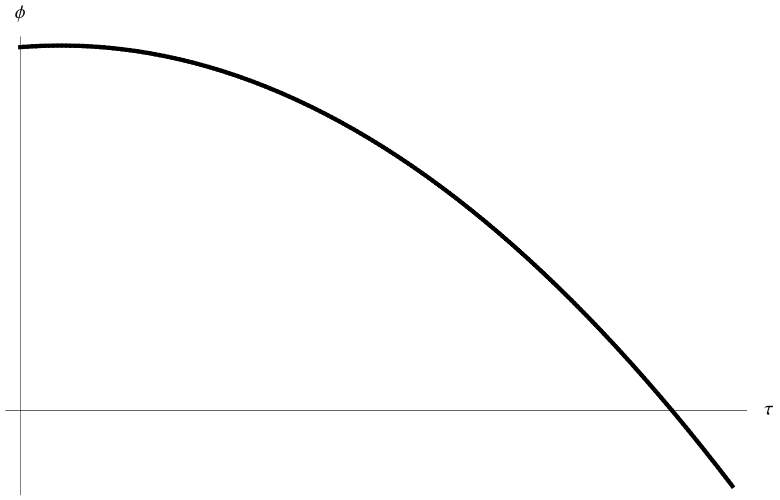

Figure 5: $\delta = 0.85$