Intellectual property rights, southern innovation and foreign direct investment

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Abstract: In a North-South trade model, we analyze the effect of a stronger Southern patent system on the Northern firm’s incentive for foreign direct investment (FDI). A stronger Southern patent regime increases the Southern firm’s incentive for innovation. For a given Southern patent system, the incentive for innovation by the Southern firm is lower under FDI than under exporting by the Northern firm. The effect of a stronger patent regime on the incentive for FDI depends on the innovative capability of the Southern firm, on the degree of product differentiation and on the transportation cost. If the Southern firm does innovation either irrespective of the Southern patent regime (which occurs for sufficiently low cost of innovation) or only under a strong Southern patent protection (which occurs for a moderate cost of innovation), a stronger patent protection may reduce the Northern firm’s incentive for FDI.

Key Words: Foreign direct investment; Innovation; Patent protection

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1. Introduction

A fascinating development in recent decades is the dominance of foreign direct investment (FDI) over international trade (UNCTAD, 2006), which has generated a vast theoretical and empirical literature on FDI. A factor which is often considered to be an important determinant of FDI is the protection of intellectual property rights. Since the developed-country firms make use of their intellectual-property related assets under FDI, a common concern of those firms is about the patent protection in the developing countries. Since the inception of the Uruguay round of the General Agreement on Tariffs and Trade, developing countries are increasingly urged to strengthen their patent systems in order to standardize the patent regime across the world, thus trying to protect the intellectual properties of the developed-country firms.

The empirical evidence is mixed on patent protection and FDI. While the empirical studies by Lee and Mansfield (1996), Maskus (1998) and Smarzynska (2004) provide support for the positive relationship between patent protection and FDI, other works show that there is either a negative (see, Yang and Maskus, 2001, Pfister and Deffains, 2005) or an insignificant (see, Seyoum, 1996 and Fosfuri, 2004) relationship between these two. The availability of technology licensing is identified as the reason for lower FDI in the presence of a stronger Southern patent system. Nunnenkump and Spatz (2004) show that industry as well as the host-country characteristics play important roles in determining the relationship between FDI and patent.

1 See, Saggi (2002) for a recent survey on FDI.
We develop a simple North-South model of international oligopoly in the presence of product innovation by the Southern firm. A stronger patent protection in the South increases the incentive for Southern innovation. Further, for a given Southern patent system, the incentive for innovation by the Southern firm is lower under FDI than under exporting by the Northern firm. This is in line with the empirical evidence (Veugelers and Houte, 1990 and Goto and Odagiri, 2003). However, whether a stronger patent protection in the South increases the incentive for FDI by the Northern firm depends on the innovative capability of the Southern firm, on the degree of product differentiation and on the transportation cost. If the Southern firm innovates either irrespective of the Southern patent regime (which occurs for sufficiently low cost of innovation) or only under strong Southern patent protection (which occurs for a moderate cost of innovation), the Northern firm’s incentive for FDI may be higher under the weak Southern patent protection depending on the degree of product differentiation and the transportation cost.

In a theoretical work, Glass and Saggi (2002) show that a stronger patent protection in the South absorbs more Southern resources for imitation, thus crowding out FDI, which, in turn, moves resources in the North from innovation to production and reducing Northern innovation. Higher cost if imitation in the South and lower Northern innovation are responsible for the FDI reducing effect of a stronger Southern patent regime in Glass and Saggi (2002). In contrast, our results are due to a new factor, viz., the innovative activity of the Southern firm, which has so far been ignored in the literature. In our analysis, imitation is costless and a stronger patent protection in the South reduces imitation exogenously (as in Helpman, 1993 and Lai, 1998).  

2 The switch from the process patent regime to product patent regime in many developing countries such as in India may justify this assumption. While process patent allows the imitator to produce a product similar to that of the innovator by using a different production process, product patent completely prevents the imitator to produce the product of the innovator. Hence, in our analysis, the
Thus, we abstract our analysis from the resource effect considered in Glass and Saggi (2002), and show the implications of Southern innovation in determining the effects of the Southern patent system on FDI by the Northern firm.

In a North-South framework, Helpman (1993) and Lai (1998) also consider the effects of the patent system on FDI. However, unlike our paper, both these works ignore innovation by the Southern firms and assume that the Southern firms are only capable of doing imitation.

While imitation is prominent in the Southern countries, empirical evidence shows considerable innovative activities by the Southern firms. It is particularly important to consider innovation by the Southern firms when considering FDI in newly industrialized countries or in relatively technologically advanced developing countries. Many Asian countries such as South Korea, India and Taiwan are inventing new products those are competing with the existing products of the developed countries' firms. In an earlier study, Correa (1990) presents the main characteristics of the software market and industry in Latin America while discussing development and commercialization of software in many Latin American countries. Significant R&D efforts are also evidenced in Indian pharmaceutical industry.3 Tsai and Wang (2004) provide evidence of significant R&D efforts in Taiwan’s electronics industry. In different contexts, the importance of innovation in the less developed countries is acknowledged in Muniagurria and Singh (1997) and Zhou et al. (2002). Hence, one-size-does not fit all, and we may need to consider Southern innovation while analyzing the effects of Southern patent regimes on FDI by Northern firms.

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3 Rajesh Unnikrishnan reports, “Domestic giant Ranbaxy Laboratories tops the list of companies from developing nations in filing patents. The company has filed patents for 240 products. … According to the Patent Cooperation Treaty (PCT) database, Indian drug companies have filed around 4,200 applications. Of these, 55% are for pharmaceutical innovations” (The Financial Express, December 13, 2004).
Our paper is related to the vast theoretical literature analyzing the effects of the patent system in the North-South trading environment (see, e.g., Chin and Grossman, 1990, Segerstrom et al., 1990, Diwan and Rodrik, 1991, Grossman and Helpman, 1991, Deardorff, 1992, Taylor, 1994, Vishwasrao, 1994, Fosfuri, 2000, Markusen, 2001 and Sinha, 2006). However, a common feature of those works is to ignore FDI by the Northern firms and innovation by the Southern firms, which are the ingredients of our analysis.

The remainder of the paper is organized as follows. Section 2 describes the model. Section 3 determines the profits of the firms conditional on the R&D decision of the Southern firm and the FDI decision of the Northern firm. Section 4 determines the equilibrium R&D decision of the Southern firm. Section 5 shows the effects of the Southern patent system on the FDI decision of the Northern firm. Section 6 concludes. Proofs are relegated to the appendix.

2. The Model

Consider two countries, called North and South. Assume that there is a firm in each of North and South and call the firms as N and S respectively. For simplicity, we assume that at the beginning of the game neither firm has any technology to produce a good. The firms can invest in R&D to invent new technologies.

Let firm N targets to invent product x, while firm S targets to invent product y. We consider that the products x and y are imperfect substitutes. We assume that each firm can invent a single product at one point of time, which implies a restriction on

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4 The assumption of imperfect substitutes can be consistent with a strong patent if we consider that the degree of substitutability depends on the tastes and preferences of the consumers. For example, even if the manual typewriter is different from the electronic typewriter or computer, these products may be imperfect substitutes depending on the tastes and preferences of the consumers. Evidences can also be found from the pharmaceutical industry where two different drugs can solve some common problems. For example, both Zantac and Gaviscon solve the problem of acidity, and become substitutes.
the R&D capacity of the firms. Since x and y are imperfect substitutes, each firm would prefer to invent the technology which is different from its competitor.6

Assume that firm N is more capable in doing innovation and requires lower investment for R&D. We assume that the R&D investment of firm N is $R_N \geq 0$ and firm S needs to spend $R$ amount more than firm N, where $R > 0$. The cost of R&D to firm S is $R_S = R_N + R$. This is consistent with the previous works where the firms in the developed countries do R&D at a lower cost, which reflect their higher capabilities in R&D, and are more prone to innovation (see, e.g., Muniagurria and Singh, 1997, and Zhou et al., 2002). To economize on the notation, we normalize the cost of R&D of firm N to 0. This simplification will not affect our analysis as long as firm N always does innovation in equilibrium.

Assume that a firm can imitate the technology invented by the other firm, if the patent law permits. We will consider two types of patent regimes in the South: weak patent protection and strong patent protection. Under strong patent protection in the South, only the patent holder of the product can sell its product in the Southern market, thus eliminating imitation. However, under weak patent protection in the South, along with innovation, both firms are allowed to do non-infringing imitation of the competitor’s technology and can sell the same product in the South. As already mentioned in footnote 2, the strong and weak patent regimes in our analysis can approximate the product and process patents respectively. Where product patent prevents the imitator to produce the product of the innovator, process patent allows

5 In real world, we don’t find one firm is investing in all the products. This may be due to strategic reasons, or may be due to physical or financial constraints on R&D. We assume the latter and consider that each firm can invent a single product at any point of time.
6 There may be a coordination problem in the R&D stage, i.e., which firm will invent which technology. However, the flow of information at the R&D stage and slight early investment of one firm may solve this coordination problem. We assume away this coordination problem by considering a predetermined choice of technology development, since the coordination problem does not add anything to the main purpose of this paper.
the imitator to produce the product of the innovator with a non-infringing production process. We assume that both firms are symmetric with respect to imitation and, for simplicity, we assume that the cost of imitation is 0. Our assumption of zero imitation cost is not crucial for our result as long as the cost of imitation is exogenous and generates imitation as the equilibrium outcome whenever the patent law permits non-infringing imitation.

Assume that the firms compete in the Southern market, and the representative consumer’s utility depends on the consumption of $x$, $y$ and a numeraire good $m$, and it is given by $U(x, y) + m$ with $U(x, y) = a(x + y) - \frac{x^2}{2} - \frac{y^2}{2} - \gamma xy$, where $\gamma$ shows the degree of product differentiation. The products are perfect substitutes for $\gamma = 0$, and they are isolated for $\gamma = 1$. Since we consider the goods $x$ and $y$ as different, we concentrate on $\gamma \in [0,1]$.

Given the utility function, the inverse market demand functions for $x$ and $y$ are respectively

$$P_x = a - x - \gamma y, \quad (1a)$$

$$P_y = a - y - \gamma x, \quad (1b)$$

where $P_x$ and $P_y$ are the prices of $x$ and $y$. For simplicity, we normalize the constant average costs of production for both $x$ and $y$ to zero.

We assume that firm $N$ may either relocate its production to the southern country (called FDI), or produce in the North and export to the south. FDI requires a

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9 This utility function is due to Bowley (1924), and is typical in the literature (see, e.g., Singh and Vives, 1984). Note that $x = x_N + x_S$ ($y = y_N + y_S$), and $x_N$ and $x_S$ ($y_N$ and $y_S$) are the outputs of $x$ ($y$) by firms N and S respectively.
fixed investment, \( F_{10} \), while exporting by firm N involves a transportation cost, \( t \). In order to avoid corner solutions, we assume that \( t \) is low enough to always ensure positive output by firm N. For our analysis, it means

\[
t < \frac{a}{2}.
\]  

(2)

We consider the following four-stage game. At stage 1, firm N decides whether to export or to undertake FDI. At stage 2, the firms take their decision on R&D to invent technology for a new product. Given our assumption that the R&D cost of firm N is 0, firm N will always do R&D. Therefore, the R&D decision is effectively for firm S only. At stage 3, imitation occurs if the patent law permits. At stage 4, the firms compete in the product market like Cournot duopolists. We solve the game through backward induction.

3. Profits of the firms

3.1. No innovation by the Southern firm

Let us first consider the situation where the firm S doesn’t do innovation. However, firm S can imitate the product of firm N under weak patent in the South.

3.1.1. Strong patent protection in the South

Under strong patent protection in the South, imitation is not an option to the firms, and only firm N sells its product as a monopolist. The outputs of firm N under export and under FDI are \( \left( \frac{a-t}{2} \right) \) and \( \left( \frac{a}{2} \right) \) respectively. The profits of firm N under export and under FDI are respectively:

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10 \( F \) captures all the start-up costs of a new plant, including the adjustment cost of learning to operate in a new institutional and financial environment.
\[ \Pi_{N}^{\text{strong(NI)}} = \left( \frac{a-t}{2} \right)^2 \]  

\[ \Pi_{N}^{\text{strong(NI)}} = \left( \frac{a}{2} \right)^2 - F. \]  

3.1.2. Weak patent protection in the South

Weak patent protection in the South allows non-infringing imitation, and firm S imitates the technology of firm N. We assume that imitation allows the imitator to produce a perfect substitute of the innovator’s product.\(^{11}\)

Note that we have assumed that imitation occurs irrespective of export and FDI by firm N. Though a more general approach would perhaps consider that imitation would be more effective under FDI than under export, might be because of the distance between the firms, it must be clear that this situation would make FDI more likely under a strong Southern patent protection by reducing imitation under FDI. However, we assume away this bias on imitation under export and FDI.

Under Export

If firm N exports, firms N and S maximize the following expressions respectively to determine their outputs:

\[ \text{Max}(a - x_N - x_S - t) x_N \]  

\[ \text{Max}(a - x_N - x_S) x_S. \]  

\(^{11}\) It is possible that even if imitation helps the firms to use similar production technologies, the products may be differentiated due to the factors such as brand names, after sales service, etc. However, it is reasonable to assume that if the firms invent different technologies for different products, these products are supposed to be more differentiated than the products produced by the imitated technologies. While both technological and non-technical factors are responsible to make the products differentiated under the former, only the non-technical factors are responsible for product differentiation under the latter. To keep the matter as simple as possible without losing the main insights, we assume that the firms produce homogeneous products under imitation, while their products are differentiated if they use technologies for different products.
The equilibrium outputs can be found as

\[ x_{N}^{\text{weak (NI)}} = \left[ \frac{a - 2t}{3} \right] \quad \text{and} \quad x_{S}^{\text{weak (NI)}} = \left[ \frac{a + t}{3} \right]. \]  

(7)

The equilibrium profits of the firms are

\[ \Pi_{N}^{\text{weak (NI)}} = \left[ \frac{a - 2t}{3} \right]^2 \quad \text{and} \quad \Pi_{S}^{\text{weak (NI)}} = \left[ \frac{a + t}{3} \right]^2. \]  

(8)

**Under FDI**

If firm N undertakes FDI, firms N and S maximize the following expressions respectively to determine their outputs:

\[ \begin{align*}
\text{Max}(a - x_{N} - x_{S})x_{N} - F \\
\text{Max}(a - x_{N} - x_{S})x_{S}.
\end{align*} \]  

(9, 10)

The equilibrium outputs can be found as

\[ x_{N}^{\text{weak (NI)}} = \left[ \frac{a}{3} \right] \quad \text{and} \quad x_{S}^{\text{weak (NI)}} = \left[ \frac{a}{3} \right]. \]  

(11)

The equilibrium profits of the firms are

\[ \begin{align*}
\Pi_{N}^{\text{weak (NI)}} = \left[ \frac{a}{3} \right]^2 - F \\
\Pi_{S}^{\text{weak (NI)}} = \left[ \frac{a}{3} \right]^2.
\end{align*} \]  

(12)

### 3.2. Innovation by the Southern firm

Let us now consider the situation where firm S innovates at stage 2. In this situation, both the firms can imitate under weak patent protection in the South.
3.2.1. Strong patent protection in the South

Under strong patent protection in the South, imitation is not a feasible option, and therefore, firms N and S produce respectively products x and y.

**Under Export**

If firm N exports, firms N and S maximize the following expressions to determine their outputs:

\[
\max_{x_N}(a - x_N - \gamma y_S - t)x_N, \tag{13}
\]

\[
\max_{y_S}(a - y_S - \gamma x_N)y_S. \tag{14}
\]

The equilibrium outputs can be found as

\[
x_N^{\text{strong}} = \frac{a(2 - \gamma) - 2t}{4 - \gamma^2} \quad \text{and} \quad y_S^{\text{strong}} = \frac{a(2 - \gamma) + \gamma t}{4 - \gamma^2}. \tag{15}
\]

The equilibrium profits of the firms are

\[
\Pi_N^{\text{strong}} = \left[\frac{a(2 - \gamma) - 2t}{4 - \gamma^2}\right]^2 \quad \text{and} \quad \Pi_S^{\text{strong}} = \left[\frac{a(2 - \gamma) + \gamma t}{4 - \gamma^2}\right]^2 - R. \tag{16}
\]

**Under FDI**

If firm N undertakes FDI, firms N and S maximize the following expressions to determine their outputs:

\[
\max_{x_N}(a - x_N - \gamma y_S)x_N - F \quad \tag{17}
\]

\[
\max_{y_S}(a - y_S - \gamma x_N)y_S. \tag{18}
\]

The equilibrium outputs can be found as

\[
x_N^{\text{strong}(1)} = \frac{a}{2 + \gamma} \quad \text{and} \quad y_S^{\text{strong}(1)} = \frac{a}{2 + \gamma}. \tag{19}
\]

The equilibrium profits of the firms are
\[ \Pi_N^{\text{weak}(I)} = \left[ \frac{a}{2 + \gamma} \right]^2 - F \quad \text{and} \quad \Pi_S^{\text{weak}(I)} = \left[ \frac{a}{2 + \gamma} \right]^2 - R. \] (20)

3.2.2. Weak patent protection in the South

If there is innovation by the Southern firm and there is weak patent protection in the South, firm S (firm N) imitates the product of firm N (firm S). Hence, each firm sells two goods (own innovated good and the imitated good of the rival).

**Under Export**

If firm N exports, firms N and S maximize the following expressions to determine their outputs:

\[
\begin{align*}
\max_{x_N,y_N} & \quad (a-x_N-x_S-\gamma y_N-\gamma y_S-t)x_N + (a-y_N-y_S-\gamma x_N-\gamma x_S-t)y_N \\
\max_{x_S,y_S} & \quad (a-x_N-x_S-\gamma y_N-\gamma y_S)x_S + (a-y_N-y_S-\gamma x_N-\gamma x_S)y_S
\end{align*}
\] (21) (22)

Differentiating (21) with respect to \(x_N, y_N\) and solving for \(x_N, y_N\) we get the profit maximizing outputs as

\[
x_N = \frac{1}{2} \frac{a(1-\gamma)-t(1-\gamma)-x_S(1-\gamma^2)}{(1+\gamma)(1-\gamma)} \quad \text{and} \quad y_N = \frac{1}{2} \frac{a(1-\gamma)-t(1-\gamma)-y_S(1-\gamma^2)}{(1+\gamma)(1-\gamma)}. \] (23)

Similarly Differentiating (22) with respect to \(x_S, y_S\) and simultaneously solving for \(x_S, y_S\) we get the profit maximizing outputs as

\[
x_S = \frac{1}{2} \frac{a(1-\gamma)-x_N(1-\gamma^2)}{(1+\gamma)(1-\gamma)} \quad \text{and} \quad y_S = \frac{1}{2} \frac{a(1-\gamma)-y_N(1-\gamma^2)}{(1+\gamma)(1-\gamma)}. \] (24)

Substituting (23) into (24), and solving for \(x_N, x_S, y_S, y_N\) we get

\[
x_N^{\text{weak}(I)} = \frac{a-2t}{3(1+\gamma)} \quad \text{and} \quad x_S^{\text{weak}(I)} = \frac{a+t}{3(1+\gamma)}. \] (25)
The equilibrium profits of the firms are

\[ \Pi_{N}^{E_{\text{weak}}} = \frac{2(a-2t)^2}{9(1+\gamma)} \]  
\[ \Pi_{S}^{E_{\text{weak}}} = \frac{2(a+t)^2}{9(1+\gamma)} - R. \]  

**Under FDI**

If firm N undertakes FDI, firms N and S maximize the following expressions to determine their outputs:

\[ \text{Max}(a - x_N - x_S - \gamma y_N - \gamma y_S) x_N + (a - y_N - y_S - \gamma x_N - \gamma x_S) y_N - F \]  
\[ \text{Max}(a - x_N - x_S - \gamma y_N - \gamma y_S) x_S + (a - y_N - y_S - \gamma x_N - \gamma x_S) y_S. \]

Differentiating (29) with respect to \( x_N, y_N \) and solving for \( x_N, y_N \) we get the profit maximizing outputs as

\[ x_N = \frac{1}{2} \frac{a(1-\gamma) - x_N (1-\gamma^2)}{(1+\gamma)(1-\gamma)} \text{ and } y_N = \frac{1}{2} \frac{a(1-\gamma) - y_N (1-\gamma^2)}{(1+\gamma)(1-\gamma)}. \]  

Similarly differentiating (30) with respect to \( x_S, y_S \) and solving for \( x_S, y_S \) we get the profit maximizing outputs as

\[ x_S = \frac{1}{2} \frac{a(1-\gamma) - x_S (1-\gamma^2)}{(1+\gamma)(1-\gamma)} \text{ and } y_S = \frac{1}{2} \frac{a(1-\gamma) - y_S (1-\gamma^2)}{(1+\gamma)(1-\gamma)}. \]

Substituting (32) into (31), and solving for \( x_N, x_S, y_S \) and \( y_N \), we get

\[ x_N^{E_{\text{weak}}(1)} = \frac{1}{3} \frac{a}{(1+\gamma)} \text{ and } x_S^{E_{\text{weak}}(1)} = \frac{1}{3} \frac{a}{(1+\gamma)}. \]  
\[ y_N^{E_{\text{weak}}(1)} = \frac{1}{3} \frac{a}{(1+\gamma)} \text{ and } y_S^{E_{\text{weak}}(1)} = \frac{1}{3} \frac{a}{(1+\gamma)}. \]
The equilibrium profits of the firms are

\[ \Pi_{N}^{\text{weak (r)}} = \frac{2a^2}{9(1+\gamma)} - F \]  
\[ \Pi_{S}^{\text{weak (r)}} = \frac{2a^2}{9(1+\gamma)} - R. \]  

4. R&D decision

Now we are in position to determine the R&D decision of firm S. Recall that, since we are interested in equilibrium where firm N always does innovation, we have normalized the R&D cost of firm N to 0. Therefore, the R&D decision is effectively taken by firm S only.

4.1. Weak patent protection in the South

Conditional on FDI by firm N, the comparison of the profits of firm S under weak patent protection in the South (see (12) and (12)) gives us that, firm S does innovation if

\[ R < \frac{2}{9} \frac{a^2}{1+\gamma} - \frac{a^2}{9} = R_{\text{FDI}}^{\text{weak}}. \]  

Similarly, comparing (8) and (28), we get that, conditional on export by firm N, firm S does innovation under weak patent protection in the South if

\[ R < \frac{2}{9} \frac{(a+t)^2}{(1+\gamma)} - \left[ \frac{a+t}{3} \right]^2 = R_{\text{Export}}^{\text{weak}}. \]

4.2. Strong patent protection in the South

Conditional on FDI by firm N, the comparison of the profits of firm S under strong patent protection in the South (see (20)) shows that firm S does innovation if
Similarly, conditional on export by firm N, the comparison of the profits of firm S under strong patent protection in the South (see (16)) shows that firm S does innovation if

$$R < \left[ \frac{a(2-\gamma)}{4-\gamma^2} \right]^2 \equiv R_{\text{FDI}}^{\text{strong}}. \quad (39)$$

The comparison of (37), (38), (39) and (40) gives the following result immediately.

Lemma 1: We have $R_{\text{FDI}}^{\text{weak}} < R_{\text{Export}}^{\text{weak}} < R_{\text{FDI}}^{\text{strong}} < R_{\text{Export}}^{\text{strong}}$.

Proof: See Appendix A for the proof.

Lemma 1 shows that the Southern firm has lower incentive for innovation under weak patent protection than under strong patent protection. There are two ways that a strong patent protection helps to increase the incentive for R&D by firm S. On one hand, strong patent protection increases the profit of firm S under innovation by protecting its product from imitation. This is similar to the usual R&D inducing effect of a strong patent protection. On the other hand, strong patent protection reduces the profit of firm S under no innovation by eliminating imitation, thus increasing the gain of firm S from innovation.

Lemma 1 also shows that, for a given Southern patent system, the incentive for innovation by firm S is always higher under export by firm N. Since exporting by the Northern firm involves a transportation cost, the output of firm S is higher under exporting than under FDI by firm N, which, in turn, increases the Southern firm’s gain from innovation under exporting compared to FDI by firm N. This result is in
line with the empirical evidence (Veugelers and Houte, 1990 and Goto and Odagiri, 2003), and questions whether FDI is always conducive in fostering the domestic R&D.

5. Export or FDI?

Let us now determine the equilibrium production strategy of firm N. Since the production strategy of firm N affects the R&D decision of firm S, the R&D decision of firm S may play an important role in determining the equilibrium production strategy of firm N. Firm N prefers FDI to export if \( \Pi_N^F > \Pi_N^E \).

5.1. If \( R < R_{FDI}^{weak} \)

Let us first consider the case where the cost of R&D is very small so that firm S does innovation irrespective of the Southern patent system and the mode of production of firm N.

Under weak patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (27) and (35) respectively, gives the following result.

**Lemma 2:** If \( R < R_{FDI}^{weak} \) and there is weak patent protection in the South, firm N prefers FDI to exporting if and only if \( F < F_{weak}^{(1)} = \frac{2a^2}{9(1 + \gamma)} - \frac{2(a - 2t)^2}{9(1 + \gamma)} \).

Under strong patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (16) and (20) respectively, gives the following result:
Lemma 3: If \( R < R_{FDI}^{\text{weak}} \) and there is strong patent protection in the South, firm N prefers FDI to exporting if and only if

\[
F < F_{FDI}^{\text{strong(h)}} = \left( \frac{a}{2 + \gamma} \right)^2 - \left( \frac{a(2 - \gamma) - 2\gamma}{4 - \gamma^2} \right)^2.
\]

The following proposition compares firm N’s incentive for FDI under weak and under strong patent protection in the South when firm S always innovates.

Proposition 1: If the R&D cost of innovation is small enough (i.e., \( R < R_{FDI}^{\text{weak}} \)), firm N’s incentive for FDI is higher under strong patent protection in the South if

\[
t > t = \frac{a(14 - 9\gamma - 7\gamma^2 + 2\gamma^4)}{23 - 9\gamma - 16\gamma^2 + 2\gamma^4}
\]

and \( \gamma > \gamma^* \approx 0.753 \). Otherwise, firm N’s incentive for FDI is higher under weak patent protection in the South.

Proof: See Appendix B for the proof.

Thus, we see that the FDI incentive of firm N is higher under weak patent protection in the South if either product differentiation is sufficiently large (i.e., \( \gamma \) is sufficiently small) or the transportation cost is sufficiently small (i.e., \( t \) is sufficiently small). This result may be explained as follows. For any \( \gamma \in [0,1) \), the profit of firm N is higher under strong patent protection in the South compared to weak patent protection in the South, irrespective of exporting and FDI by firm N. Further, while the profit under FDI is independent of \( t \), the profit of firm N under export reduces with \( t \) for two reasons. First, given the outputs, a higher \( t \) reduces the per-unit profit of firm N. Second, given the per-unit profit of firm N, a higher \( t \) reduces its output and profit.
If $t \to 0$, the output of firm N is *almost* the same under exporting and FDI, for both weak and strong patent protection. In this situation, the output effect of a higher $t$ becomes the important factor, and the loss of market share under export due to a rise in $t$ is more under weak patent protection compared to strong patent protection. As a result, if $t \to 0$, firm N’s relative benefit from FDI over export is higher under weak patent protection compared to strong patent protection, thus creating higher incentive for FDI under weak patent protection for $\gamma \in [0,1)$ and $t \to 0$.

If $t = \frac{a}{2}$, the output and profit of firm N under export tend to zero if there is weak patent protection in the South, while they are positive under strong patent protection, for any $\gamma \in [0,1)$. In this situation, the profit gain of firm N under export due to a lower $t$ is negligible under weak patent protection, while it is significant under strong patent protection. However, if $\gamma \to 0$, firm N’s gain in profit due to the strong patent protection is higher under export than under FDI. While negligible competition due to a large product differentiation increases firm N’s profit significantly under strong patent protection for both FDI and exporting, it only increases firm N’s profit under FDI significantly for weak patent protection. As a result, firm N’s profit difference between FDI and exporting is higher under weak patent protection than under strong patent protection. If $\gamma \to 1$, competition between the products are severe and the profits of firm N are very much similar under weak and strong patent protection for FDI and for exporting. However, in this situation, firm N’s profit difference between FDI and exporting is higher under strong patent protection than under weak patent protection.
5.2. If $R_{FDI}^{\text{weak}} < R < R_{\text{Export}}^{\text{weak}}$

Let us now consider the case where the cost of R&D is such that firm S does not innovate under weak patent protection if firm N undertakes FDI. Otherwise, firm S innovates always.

Under weak patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (27) and (12) respectively, gives the following result.

**Lemma 4:** If $R_{FDI}^{\text{weak}} < R < R_{\text{Export}}^{\text{weak}}$ and there is weak patent protection in the South, firm N prefers FDI to exporting if and only if $F < F_{3}^{\text{weak (NI)}} \equiv \left( \frac{a}{3} \right)^{2} - \frac{2(a - 2t)^{2}}{9(1 + \gamma)}$.

Under strong patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (16) and (20) respectively, gives the following result:

**Lemma 5:** If $R_{FDI}^{\text{weak}} < R < R_{\text{Export}}^{\text{weak}}$ and there is strong patent protection in the south, firm N prefers FDI to exporting if and only if $F < F_{4}^{\text{strong (1)}} \equiv \left( \frac{a}{2 + \gamma} \right)^{2} - \left( \frac{a(2 - \gamma) - 2t}{4 - \gamma^{2}} \right)^{2}$.

The following proposition compares firm N’s incentive for FDI under weak and under strong patent protection in the South when firm S does not innovate under weak patent protection if firm N undertakes FDI.
Proposition 2: If the cost of innovation is such that $R_{FDI}^{weak} < R < R_{Export}^{weak}$, firm N’s incentive for FDI is higher under strong patent protection in the South.

Proof: See Appendix C for the proof.

The intuition for the above result is as follows. Consider weak patent protection in the South. If the cost of innovation is such that firm S does not innovate under FDI by firm N, the profit of firm N under FDI reduces compared to the situation where firm S innovates under FDI by firm N. This is because, in the latter situation, firm S gets the opportunity to produce the product of firm S, while no innovation by firm S eliminates that possibility. As a result, if firm S does not innovate when firm N undertakes FDI and there is weak patent protection in the South, strong patent protection in the South always increases firm N’s incentive for FDI.

5.3. If $R_{Export}^{weak} < R < R_{FDI}^{strong}$

Let us now consider the situation where the cost of innovation is such that firm S innovates only under strong patent protection in the South, irrespective of exporting or FDI by firm N.

Under weak patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (8) and (12), gives the following result:

Lemma 6: If $R_{Export}^{weak} < R < R_{FDI}^{strong}$ and there is weak patent protection in the South, firm $N$ prefers FDI to exporting if and only if $F < F_{5}^{weak (NI)} = \frac{a^2}{9} - \frac{(a - 2t)^2}{9}$. 
Under strong patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (16) and (20) respectively, gives the following result:

**Lemma 7:** If $R_{\text{Export}}^{\text{weak}} < R < R_{\text{FDI}}^{\text{strong}}$ and there is strong patent protection in the South, firm N prefers FDI to exporting if and only if

$$F < F_{6}^{\text{strong}(t)} \equiv \left( \frac{a}{2 + \gamma} \right)^{2} - \left( \frac{a(2 - \gamma) - 2t}{4 - \gamma^{2}} \right)^{2}.$$

The following proposition compares firm N’s incentive for FDI under weak and under strong patent protection in the South when firm S innovates only under strong patent protection in the South.

**Proposition 3:** If the cost of innovation is such that $R_{\text{Export}}^{\text{weak}} < R < R_{\text{FDI}}^{\text{strong}}$, firm N’s incentive for FDI is higher under strong patent protection in the South if either

$$\gamma < \frac{\sqrt{13} - 3}{2} \quad \text{or} \quad \gamma > \frac{\sqrt{13} - 3}{2} \quad \text{and} \quad t > \bar{t} \equiv \frac{a(-2 + 9\gamma - 8\gamma^{2} + \gamma^{4})}{7 - 8\gamma^{2} + \gamma^{4}}.$$

**Proof:** See Appendix D for the proof.

Proposition 3 can be explained as follows. Strong patent protection in the South eliminates imitation but encourages innovation by the Southern firm. Hence, the strong patent protection helps to increase the profit of firm N under both export and FDI, since the product differentiation is higher under Southern innovation than under imitation. If the products are sufficiently differentiated, the profit gain for firm N under strong patent protection (compared to weak patent protection) is higher under
FDI compared to exporting, since the trade cost creates the distortion under exporting. However, if the products are not very much differentiated, firm N’s profit gain under strong patent protection is higher under FDI compared to exporting provided exporting creates significant distortion, which happens for sufficiently high transportation cost. Therefore, if the products are not very differentiated and the transportation cost is sufficiently small, firm N’s profit gain under strong patent protection is higher under exporting compared to FDI, thus creating higher FDI incentive under weak patent protection in this situation.

5.4. If $R_{\text{FDI}}^{\text{strong}} < R < R_{\text{Export}}^{\text{strong}}$

Let us now consider the case where firm S innovates only when firm N exports and there is strong patent protection in the South.

Under weak patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (8) and (12) respectively, gives the following result:

**Lemma 8:** If $R_{\text{FDI}}^{\text{strong}} < R < R_{\text{Export}}^{\text{strong}}$ and there is weak patent protection in the South, firm N prefers FDI to exporting if and only if $F < F_{\text{weak (NI)}}^{(a)} \equiv \frac{a^2}{9} - \frac{(a - 2t)^2}{9}.

Under strong patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (16) and (4) respectively, gives the following result:
Lemma 9: If $R_{FDI}^{\text{strong}} < R < R_{\text{Export}}^{\text{strong}}$ and there is strong patent protection in the South,

firm N prefers FDI to exporting if and only if $F < R_{8}^{\text{strong (NI)}} = \left( \frac{a}{2} \right)^2 - \left( \frac{a(2 - \gamma) - 2t}{4 - \gamma^2} \right)^2$.

The following proposition compares firm N’s incentive for FDI under weak and under strong patent protection in the South when firm S innovates only when firm N exports and there is strong patent protection in the South.

Proposition 4: If the cost of innovation is such that $R_{FDI}^{\text{strong}} < R < R_{\text{Export}}^{\text{strong}}$, firm N’s incentive for FDI is higher under strong patent protection in the South for all feasible values of $t$ and $\gamma$.

Proof: See Appendix E for the proof.

Intuitively, the above result can be explained as follows. As usual, strong patent protection helps to protect the product of firm N, which creates an incentive for FDI. Moreover, since firm S innovates only if there is strong patent protection and firm N exports, FDI by firm N under strong patent protection eliminates product market competition by deterring Southern innovation, thus encouraging firm N to undertake FDI under strong patent protection.

5.5. If $R > R_{\text{Export}}^{\text{strong}}$

Finally, consider the situation where firm S does not do innovation irrespective of the patent system in the South and the production strategy of firm N. This case corresponds to the previous works where the Southern firm can only imitate the product of the Northern firm.
Under weak patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (8) and (12) respectively, gives the following result:

**Lemma 10:** If $R > R_{\text{Export}}^{\text{strong}}$ and there is weak patent protection in the South, firm N prefers FDI to exporting if and only if $F < F_{y}^{\text{weak}(N)} = \frac{a^2}{9} - \frac{(a - 2t)^2}{9}$.

Under strong patent protection in the South, the comparison of the profits of firm N under export and under FDI, shown in (16) and (4) respectively, gives the following result:

**Lemma 11:** If $R > R_{\text{Export}}^{\text{strong}}$ and there is strong patent protection system in the South, firm N prefers FDI to exporting if and only if $F < F_{10}^{\text{strong}(N)} = \left(\frac{a}{2}\right)^2 - \left(\frac{a - t}{2}\right)^2$.

The following proposition compares firm N’s incentive for FDI under weak and under strong patent protection in the South when firm S never innovates irrespective of the Southern patent system and the production strategy of firm N.

**Proposition 5:** If the cost of innovation is such that $R > R_{\text{Export}}^{\text{strong}}$, firm N’s incentive for FDI is higher under strong patent protection in the South for all feasible values of $t$ and $\gamma$.

**Proof:** See Appendix F for the proof.
The above result is due to the standard argument for a strong patent protection in the South. If firm S never innovates, strong patent protection helps to protect the product of firm N, thus creating higher incentive for FDI under strong patent protection.

The following table summarizes the findings on section 5:

<table>
<thead>
<tr>
<th>R</th>
<th>$F^{\text{strong}} - F^{\text{weak}} &gt; 0$ for</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R &lt; R_{\text{FDI}}^{\text{weak}}$</td>
<td>$t &gt; \tilde{t} \equiv \frac{a(14 - 9\gamma - 7\gamma^2 + 2\gamma^4)}{23 - 9\gamma - 16\gamma^2 + 2\gamma^4}$ and $\gamma &gt; 0.75$</td>
</tr>
<tr>
<td>$R_{\text{FDI}}^{\text{weak}} &lt; R &lt; R_{\text{FDI}}^{\text{Export}}$</td>
<td>$t &gt; 0, \gamma &gt; 0$</td>
</tr>
<tr>
<td>$R_{\text{Export}}^{\text{weak}} &lt; R &lt; R_{\text{FDI}}^{\text{strong}}$</td>
<td>$\gamma &lt; \frac{\sqrt{13} - 3}{2}$ or $t &gt; \tilde{t} \equiv \frac{a(-2 + 9\gamma - 8\gamma^2 + \gamma^4)}{7 - 8\gamma^2 + \gamma^4}$ and $\gamma &gt; \frac{\sqrt{13} - 3}{2}$</td>
</tr>
<tr>
<td>$R_{\text{FDI}}^{\text{strong}} &lt; R &lt; R_{\text{Export}}^{\text{strong}}$</td>
<td>$t &gt; 0, \gamma &gt; 0$</td>
</tr>
<tr>
<td>$R_{\text{Export}}^{\text{strong}} &lt; R$</td>
<td>$t &gt; 0, \gamma &gt; 0$</td>
</tr>
</tbody>
</table>

6. Conclusion

Though evidence suggests that patent protection in the host country has significant impact on the incentive for FDI, the existing theoretical literature did not pay enough attention to this issue. We take up this issue in this paper and show how the patent regimes in the host country affect the FDI incentive of a multinational.

In a North-South model, we show that innovation in the South plays an important role in determining the effect of the Southern patent system on the incentive for FDI by the Northern firm. A stronger patent protection in the South increases the incentive for innovation by the Southern firm, irrespective of FDI or export by the Northern firm. Further, for a given Southern patent system, the incentive for innovation by the Southern firm is lower under FDI than under exporting by the
Northern firm. However, the effect of the Southern patent system on the incentive for FDI by the Northern firm depends on the innovative capability of the Southern firm, on the degree of product differentiation and on the transportation cost. If the Southern firm innovates either irrespective of the Southern patent regime or only under strong patent protection in the South, the Northern firm’s incentive for FDI may be higher under weak patent protection in the South depending on the degree of product differentiation and the transportation cost. Hence, an important policy implication resulting from our paper is that the Southern countries may need to consider a trade off between FDI and domestic innovation while designing their patent policies. There are situations where a strong patent protection may deter FDI, yet increasing domestic innovation.

While our framework of an international duopoly helps us to present a simplified analysis keeping the central points in focus, the implications of more firms are easy to see. If there are multiple firms in the South, given the other specifications of the model, the market will be more competitive. If the cost of innovation is very low so that all the firms in the South innovate, the Northern firm may have higher FDI incentive under weak patent protection, since it could have more profits by imitating the Southern goods and also avoiding the transportation cost. However, when the cost of innovation increases, which reduces the possibility of new product development in the South, the incentive for FDI by the Northern firm under strong patent protection increases, since strong patent protection helps to protect the product of the Northern firm.

It is important to note that we have considered the incentive for inward FDI by the Northern firm. However, in the present economic scenario where the Southern firms are increasingly prominent in international trade and capital flows, it is
important to identify the effects of the patent regimes under two-way FDI where the Southern firms can also undertake FDI. In this respect, it would be interesting to see the implications of Northern demand and also to focus on patent harmonization. We intend to take up these issues in our future research.
Appendix

A   Proof of Lemma 1

We get from (39) and (38) that \[
\frac{\partial (R_{FDI}^{\text{strong}} - R_{Export}^{\text{weak}})}{\partial t} = - \frac{2(1 - \gamma)(a + t)}{9(1 + \gamma)} < 0. 
\]
Hence,

\[R_{FDI}^{\text{strong}} - R_{Export}^{\text{weak}}\] reaches minimum at \( t = \frac{a}{2} \), and the minimum value of \[R_{FDI}^{\text{strong}} - R_{Export}^{\text{weak}} = \frac{1}{4} a^2 \gamma \left( \frac{3\gamma + \gamma^2 + 4}{(\gamma + 1)(\gamma + 2)^2} \right) > 0, \]
which proves that \( R_{FDI}^{\text{strong}} > R_{Export}^{\text{weak}} \).

Comparing \( R_{FDI}^{\text{strong}} \) and \( R_{Export}^{\text{strong}} \) from (39) and (40), we get that \[R_{FDI}^{\text{strong}} - R_{Export}^{\text{strong}} = \frac{t\gamma}{(2 + \gamma)(2 - \gamma)} > 0, \]
which proves that \( R_{FDI}^{\text{strong}} > R_{Export}^{\text{strong}} \).

Comparing \( R_{FDI}^{\text{weak}} \) and \( R_{Export}^{\text{weak}} \) from (37) and (38), we get that \[R_{FDI}^{\text{weak}} - R_{Export}^{\text{weak}} = \frac{t(1 - \gamma)(2a + t)}{9(1 + \gamma)} > 0, \]
which proves that \( R_{Export}^{\text{weak}} > R_{FDI}^{\text{weak}} \).

Taken together, we get that \( R_{FDI}^{\text{Process}} < R_{Export}^{\text{Process}} < R_{FDI}^{\text{Product}} < R_{Export}^{\text{Product}} \). Q.E.D.

B   Proof of Proposition 1

The comparison of \( F_1^{\text{weak}(1)} \) and \( F_2^{\text{strong}(1)} \) shows that \( F_2^{\text{strong}(1)} > F_1^{\text{weak}(1)} \)
if \( t > \hat{t} = \frac{a(14 - 9\gamma - 7\gamma^2 + 2\gamma^4)}{23 - 9\gamma - 16\gamma^2 + 2\gamma^4} \). However, \( \hat{t} < t_{\max} = \frac{a}{2} \) if \( \gamma > \hat{\gamma} \approx 0.753 \). Therefore, firm N’s incentive for FDI is higher under strong patent protection in the South if \( t > \hat{t} \) and \( \gamma > 0.753 \). Otherwise, firm N’s incentive for FDI is higher under weak patent protection in the South. Q.E.D.

C   Proof of Proposition 2

Setting \( F_4^{\text{strong}(1)} = F_3^{\text{weak}(N/1)} \), we get the following two roots of \( t : \)
\[
a(14 + 5\gamma - 2\gamma^2 - 2\gamma^3 - (-2 + \gamma)^2 - 3 - 64\gamma - 7\gamma^2 + 26\gamma^3 + 14\gamma^4 + 2\gamma^5) \\
2(23 + 14\gamma - 2\gamma^2 - 2\gamma^3)
\]

\[
a(14a + 5\gamma - 2\gamma^2 - 2\gamma^3 + (-2 + \gamma)^2 - 3 - 64\gamma - 7\gamma^2 + 26\gamma^3 + 14\gamma^4 + 2\gamma^5) \\
2(23 + 14\gamma - 2\gamma^2 - 2\gamma^3)
\].

Since \(-43 - 64\gamma - 7\gamma^2 + 26\gamma^3 + 14\gamma^4 + 2\gamma^5 < 0\) for \(\gamma \in [0,1]\), neither of these roots is real, irrespective of the value of \(\gamma\). Therefore, there is no real value of \(t\) such that \(F_{4,\text{strong}(I)} = F_{3,\text{weak}(NI)}\).

Let us now take a value of \(\gamma\), say \(\gamma = 0\). We get that \(F_{4,\text{strong}(I)} > F_{3,\text{weak}(NI)}\) if \(\gamma = 0\). Hence, for any \(a\), \(t\) and \(\gamma\), we get \(F_{4,\text{strong}(I)} > F_{3,\text{weak}(NI)}\), which implies that firm N’s incentive for FDI is higher under strong patent protection. Q.E.D.

**D Proof of Proposition 3**

The comparison of \(F_{5,\text{weak}(NI)}\) and \(F_{6,\text{strong}(I)}\) shows that

\[
F_{6,\text{strong}(I)} - F_{5,\text{weak}(NI)} = \frac{a^2}{(2 + \gamma)^2} - \frac{(a(2 - \gamma) - 2t)^2}{(4 - \gamma^2)^2} - \frac{a^2}{9} + \frac{(a - 2t)^2}{9} > 0
\]

if \(t > \bar{t} \equiv \frac{a(-2 + 9\gamma - 8\gamma^2 + \gamma^4)}{7 - 8\gamma^2 + \gamma^4}\). We get \(\bar{t} < t_{\text{max}} = \frac{a}{2}\). However, \(\bar{t} > 0\) provided

\[\gamma > \frac{\sqrt{13} - 3}{2}\].

Therefore, firm N’s incentive for FDI is higher under strong patent protection if either \(\gamma < \frac{\sqrt{13} - 3}{2}\) so that \(t > 0\) is always greater than \(\bar{t}\), or \(\gamma > \frac{\sqrt{13} - 3}{2}\) and \(t > \bar{t}\). Q.E.D.
E   Proof of Proposition 4

We get that $F_{8}^{\text{strong}} > F_{10}^{\text{strong}}$ as $\left(\frac{a-t}{2}\right)^2 - \left(\frac{a(2-\gamma) - 2t}{4-\gamma^2}\right)^2 \geq 0$ for $\gamma \in [0,1)$, where

$F_{10}^{\text{strong}}$ is shown in Lemma 11. Further, we get that $F_{10}^{\text{strong}} > F_{9}^{\text{weak}} = F_{7}^{\text{weak}}$, where

$F_{9}^{\text{weak}}$ is shown in Lemma 10. Hence, it proves that $F_{8}^{\text{strong}} > F_{7}^{\text{weak}}$. Q.E.D.

F   Proof of Proposition 5

As already shown in Proposition 4, $F_{10}^{\text{strong}} > F_{9}^{\text{weak}}$, which proves the result. Q.E.D.
References


