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INTELLECTUAL PROPERTY RIGHTS, SOUTHERN INNOVATION AND FOREIGN DIRECT INVESTMENT

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ABSTRACT

While empirical evidence shows considerable innovative activities by the Southern firms, these activities have been ignored in determining the relationship between Southern patent regime and foreign direct investment (FDI) by the Northern firms. We show that whether a stronger Southern patent regime increases a Northern firm's incentive for FDI depends on the innovative capability of the Southern firm, the degree of product differentiation and the transportation cost. If either the cost of Southern innovation is sufficiently low such that the Southern firm innovates irrespective of the Southern patent regime and the production strategy of the Northern firm, or the Southern firm's cost of innovation is moderate such that it innovates only under a stronger Southern patent regime, a stronger Southern patent regime may reduce the Northern firm's incentive for FDI. For other costs of Southern innovation, a stronger Southern patent regime increases the Northern firm's incentive for FDI.

Keywords: Foreign direct investment; Innovation; Patent protection
JEL Classification: F12; F13; O32; O34

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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.[1] 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, it is generally believed that a stronger patent regime in the developing country encourages FDI to that country by protecting the intellectual-property related assets of the investors. Since the inception of the Uruguay round of the General Agreement on Tariffs and Trade, developing countries are increasingly urged to strengthen their patent regimes in order to standardize the patent regime across the world, thus trying to protect the intellectual properties of the developed-country firms.

Empirical evidence is however mixed on the effects of patent protection on FDI. The empirical studies by Lee and Mansfield (1996), Maskus (1998) and Smarzynska (2004) show a positive relationship between patent protection and FDI, while there are other works showing 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. Technology licensing is identified as the reason for lower inward FDI following a stronger host-country patent regime. 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 protection.

In this paper, we focus on a new factor, viz., the innovative capability of the host-country firm, which has not been paid due attention in the literature, yet may play an important role in determining the relationship between the host-country patent

[1] See, Saggi (2002) for a recent survey on FDI.

regime and inward FDI. No innovation by the Southern firm, as considered in the existing literature, comes out as a special case of our analysis. We show that if either the cost of Southern (or developing-country) innovation is sufficiently low such that the Southern firm innovates irrespective of the Southern patent regime and the production strategy of the Northern (or developed-country) firm, or the Southern firm's cost of innovation is moderate such that it innovates only under a stronger Southern patent regime, a stronger Southern patent regime may reduce the Northern firm's incentive for FDI. For other costs of Southern innovation, a stronger Southern patent regime increases the Northern firm's incentive for FDI. Thus, our paper suggests that a blanket approach for strengthening Southern patent protection in order to attract inward FDI may not be justifiable, if the innovative capability of the Southern firm is high. To attract FDI, a patent policy may need to be complemented by other policies increasing the benefit of FDI.

If the Southern firm innovates irrespective of the Southern patent regime and the production strategy of the Northern firm, a stronger Southern patent regime reduces the number of products produced by the Northern firm by preventing knowledge spillover. If the products are sufficiently differentiated, the reduced product range of the Northern firm under a stronger Southern patent regime may reduce the Northern firm's net benefit from FDI over exporting compared to a weak Southern patent regime. Thus, a strong Southern patent regime may reduce the Northern firm's incentive for FDI.

If the Southern firm innovates only under a stronger Southern patent regime, the number of products produced by the Northern firm is not affected by the Southern patent regime. However, a stronger Southern patent regime helps to increase the profit of the Northern firm under both FDI and exporting by reducing the intensity of competition between the firms, since the degree of product differentiation is higher

under the stronger patent regime. If the products are not very much differentiated and the output distortion under exporting, because of the transportation cost, is not very high, the Northern firm's net benefit under the strong patent regime compared to the weak patent regime is higher under exporting than FDI. As a result, a stronger Southern patent regime reduces the Northern firm's incentive for FDI compared with the weak Southern patent regime.

While knowledge spillover is prominent in Southern countries, empirical evidence shows considerable innovative activities in many developing and newly industrialized countries such as South Korea, India, China, Taiwan and some Latin American countries. Correa (1990) presents the main characteristics of the software industry in Latin America while discussing development and commercialization of software in many Latin American countries. Significant innovative activities are evidenced in Indian pharmaceutical industry (The Financial Express, December 13, 2004).[2] Tsai and Wang (2004) provide evidence of significant innovative activities in Taiwan's electronics industry. Wei et al. (2008) provide the evidence of innovation by Chinese motorcycle companies. Innovation in the less developed countries is also acknowledged in Muniagurria and Singh (1997), Zhou et al. (2002) and Chen and Puttitanun (2005).

Even if the innovative activities of many developing and newly industrialized countries are becoming more prominent in recent years, the literature on patent protection is yet to appreciate their implications on inward FDI. To the best of our knowledge, this is the first paper that considers the implications of Southern innovation

[2] 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. The move assumes significance as the product patent regime comes into force next month. According to the Patent Cooperation Treaty (PCT) database, Indian drug companies have filed around 4,200 applications. Of these, 55% are for pharmaceutical innovations".

in determining the effects of Southern patent regime on the incentive for FDI by the Northern firm.

Glass and Saggi (2002) show that a stronger patent protection in the South absorbs more Southern resources for imitation, thus crowding out inward FDI, which, in turn, moves resources in the North from innovation to production and reducing Northern innovation. Hence, in their resource-based analysis, higher cost of imitation in the South and lower Northern innovation are responsible for the FDI reducing effect of a stronger Southern patent regime. In contrast, the innovative activity of the Southern firm is the key factor for our results. We consider that knowledge spillover (or imitation) is costless and a stronger Southern patent protection reduces the degree of knowledge spillover exogenously, as in Helpman (1993) and Lai (1998).[3] Thus, we abstract our analysis from the resource effect considered in Glass and Saggi (2002), and show the roles played by Southern innovation.

Helpman (1993) shows that a stronger Southern patent regime increases the products of the Northern multinationals. Lai (1998) shows that a stronger Southern patent regime encourages FDI by Northern firms. Yang and Maskus (2009) show the effects of a stronger Southern patent regime on the incentive for technology licensing by a Northern firm with and without the possibility of FDI. Unlike our paper, these papers ignore Southern innovation, which is the key ingredient of our analysis.

There is a large theoretical literature analyzing the effects of patent protection in a 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,

[3] A switch from the process patent regime to product patent regime in many developing countries such as in India may also 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 stronger patent protection can be viewed as an approximation for the product patent regime, while the weaker patent regime can be viewed as an approximation for the process patent regime.

Taylor, 1994, Vishwasrao, 1994, Eaton and Kortum, 1999, Fosfuri, 2000, Markusen, 2001 and Sinha, 2006). However, these works ignore the impact on FDI, which is our main focus.

The remainder of the paper is organized as follows. Section 2 describes the model. Section 3 determines the equilibrium R&D decision of the Southern firm. Section 4 shows the effects of the Southern patent regime on the Northern firm's FDI decision, followed by some remarks in Section 5. Section 6 concludes. The 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. However, the firms can invent new technologies.

Let firm *N* wants to invent product *x*, while firm *S* wants to invent product *y*. We consider that the products *x* and *y* are imperfect substitutes.[4] We assume that each firm can invent a single product at one point of time, which implies a restriction on the R&D capacity of the firms.[5] Since *x* and *y* are imperfect substitutes, each firm would prefer to invent the technology which is different from its competitor.[6]

[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.

[5] Invention of some but not all products may be for strategic reasons or 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 pre-determined choice of technology development, since the coordination problem does not add anything to the main purpose of this paper.

Assume that firm N is more capable in doing innovation and requires lower R&D investment. 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. The cost of R&D to firm S is then $R_S = R_N + R$. 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, Zhou et al., 2002 and Chen and Puttitanun, 2005).[7] 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 innovates in equilibrium.

Assume that the firms compete in the Southern market. 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 γ shows the degree of product differentiation.[8] The products are perfect substitutes for $\gamma = 1$, and they are isolated for $\gamma = 0$. Since we consider the goods x and y as different, we concentrate on $\gamma \in [0,1)$.

The inverse market demand functions for x and y are respectively

$$P_x = a - x - \gamma y, \tag{1a}$$

$$P_y = a - y - \gamma x, \tag{1b}$$

[7] As documented in Chen and Puttitanun (2005), "during 1985-1995, the number of [patent] applications was 2757 in Brazil, 1545 in India, 5549 in South Africa, and 59249 in South Korea; as compared to 9325 in Australia, 3039 in Canada, 335061 in Japan, and 127476 in the US during the same period."

[8] 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.

where P_x and P_y are prices of x and y. For simplicity, we normalize the marginal costs of production for both x and y to zero. We also assume that there are no other costs related to production and innovation.

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 fixed investment, F,[9] while exporting by firm N involves a per-unit transportation cost, t. In order to avoid corner solutions, we assume that t is low enough to ensure positive outputs by firm N. For our analysis, it means that

$$t < \frac{a}{2}. \tag{2}$$

We will consider two types of patent regimes in the South: a weak patent protection and a strong patent protection. Under a strong patent protection in the South, only the patent holder of a product can sell the product in the Southern market. However, under a weak patent protection, knowledge spillover helps both firms to produce and sell the same product in the South.

We assume that both firms are symmetric with respect to knowledge spillover and, for simplicity, we assume that knowledge spillover is costless. Our results will hold even if knowledge spillover is costly but both firms are producing and selling the same product is an equilibrium outcome under the weak patent regime.

Under each type of patent regime, we consider the following game. At stage 1, firm N decides whether to export or to undertake FDI. At stage 2, the firms take decisions on R&D. 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, knowledge spillover occurs if there is a weak patent regime. At stage 4, the firms

[9] 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.

compete in the product market like Cournot duopolists. We solve the game through backward induction.

3. R&D decision of the firms

3.1. A strong Southern patent regime

First consider the game under a strong Southern patent regime. There is no knowledge spillover in this situation.

Consider the situation under exporting by firm *N*. If firm *S* does not innovate, i.e., only firm *N* produces, the equilibrium outputs of firm *N* can be found as $\left(\frac{a-t}{2}\right)$, and its profit is

$$\Pi_N^{E^{strong\ (NI)}} = \left(\frac{a-t}{2}\right)^2. \tag{3}$$

However, if firm S innovates, so that firms *N* and *S* compete in the product market, the equilibrium outputs of firms *N* and *S* can be found as $x_N^{E^{strong\ (I)}} = \frac{a(2-\gamma)-2t}{(4-\gamma^2)}$ and $y_S^{E^{strong(I)}} = \frac{a(2-\gamma)+\gamma t}{(4-\gamma^2)}$ respectively. The equilibrium profits of the firms are

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

Therefore, if there is a strong Southern patent protection and firm *N* exports, firm S innovates if

$$R < \left[\frac{a(2-\gamma)+\gamma t}{(4-\gamma^2)}\right]^2 \equiv R_{Export}^{strong}. \tag{5}$$

Now consider the situation under FDI by firm *N*. If firm *S* does not innovate, the equilibrium outputs of firm *N* can be found as $\left(\frac{a}{2}\right)$ and its profit is

$$\Pi_N^{\mathrm{F}^{\mathrm{strong}(NI)}} = \left(\frac{a}{2}\right)^2 - F\,. \tag{6}$$

However, if firm *S* innovates, the equilibrium outputs of firms *N* and *S* can be found as $x_N^{\mathrm{F}^{\mathrm{strong}(1)}} = \frac{a}{(2+\gamma)}$ and $y_S^{\mathrm{F}^{\mathrm{strong}\,(1)}} = \frac{a}{(2+\gamma)}$ respectively. The equilibrium profits of the firms are

$$\Pi_N^{\mathrm{F}^{\mathrm{strong}\,(\mathrm{I})}} = \left[\frac{a}{(2+\gamma)}\right]^2 - F \quad \text{and} \quad \Pi_S^{\mathrm{F}^{\mathrm{strong}\,(\mathrm{I})}} = \left[\frac{a}{(2+\gamma)}\right]^2 - R\,. \tag{7}$$

Therefore, if there is a strong Southern patent protection and firm *N* undertakes FDI, firm *S* innovates if

$$R < \left[\frac{a(2-\gamma)}{(4-\gamma^2)}\right]^2 \equiv R_{FDI}^{\mathrm{strong}}\,. \tag{8}$$

The following result follows immediately from (5) and (8).

Lemma 1: $R_{FDI}^{strong} < R_{Export}^{strong}$.

3.2. A weak patent regime

Weak patent protection in the South creates knowledge spillover, which allows the imitator to produce a perfect substitute of the innovator's product at a marginal cost similar to that of the innovator.[10]

[10] We consider two extreme situations of knowledge spillover in our analysis. As an alternative to no knowledge spillover under a strong patent regime, the marginal cost of production of the imitator, which gets the benefit of knowledge spillover, can be considered to be very high so that production of the imitated product is unprofitable. In contrast, the marginal costs of production of the innovator and the imitator are the same under a weak patent protection. One can easily generalize this situation by assuming

We have assumed that knowledge spillover occurs irrespective of export and FDI by firm *N*. A more general approach would perhaps consider that knowledge spillover 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 knowledge spillover under FDI, yet the negative relationship between a stronger patent protection and FDI shown in the following analysis remains if the effect of distance on knowledge spillover is not very significant. However, we assume away this bias on knowledge spillover depending on export and FDI.

First, consider exporting by firm *N*. If firm *S* does not innovate, the equilibrium outputs of firms *N* and *S* are respectively $x_N^{\mathrm{E}^{\mathrm{weak(NI)}}} = \left[\frac{a-2t}{3}\right]$ and $x_S^{\mathrm{E}^{\mathrm{weak(NI)}}} = \left[\frac{a+t}{3}\right]$. The equilibrium profits of the firms are

$$\Pi_N^{\mathrm{E}^{\mathrm{weak\,(NI)}}} = \left[\frac{a-2t}{3}\right]^2 \quad \text{and} \quad \Pi_S^{\mathrm{E}^{\mathrm{weak(NI)}}} = \left[\frac{a+t}{3}\right]^2. \tag{9}$$

However, if firm *S* innovates, the equilibrium outputs of firms *N* and *S* are respectively $x_N^{E^{\mathrm{weak\,(I)}}} = \frac{a-2t}{3(1+\gamma)}$, $x_S^{E^{\mathrm{weak\,(I)}}} = \frac{a+t}{3(1+\gamma)}$, $y_N^{E^{\mathrm{weak\,(I)}}} = \frac{a-2t}{3(1+\gamma)}$ and $y_S^{E^{\mathrm{weak\,(I)}}} = \frac{a+t}{3(1+\gamma)}$. The equilibrium profits of the firms are

$$\Pi_N^{\mathrm{E}^{\mathrm{weak\,(I)}}} = \frac{2(a-2t)^2}{9(1+\gamma)} \quad \text{and} \quad \Pi_S^{\mathrm{E}^{\mathrm{weak\,(I)}}} = \frac{2(a+t)^2}{9(1+\gamma)} - R. \tag{10}$$

Therefore, if there is a weak patent protection in the Southern country and firm *N* exports, firm S innovates if

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that the marginal cost of the imitator under a weak patent protection is non-prohibitive but is higher than that of the innovator. This generalization will not eliminate the negative relationship between patent protection and FDI as long as the marginal cost difference between the innovator and the imitator is not very high under a weak patent regime. To keep the matter simple without losing any important insight, we assume that the marginal costs of the firms are the same under knowledge spillover.

$$R < \frac{2}{9}\frac{(a+t)^2}{(1+\gamma)} - \left[\frac{a+t}{3}\right]^2 \equiv R_{Export}^{\text{weak}}. \tag{11}$$

Now look at the situation under FDI by firm *N*. If firm *S* does not innovate, the equilibrium outputs of firms N and S are respectively $x_N^{\text{F}^{\text{weak(NI)}}} = \left[\frac{a}{3}\right]$ and $x_S^{\text{F}^{\text{weak(NI)}}} = \left[\frac{a}{3}\right]$. The equilibrium profits of the firms are

$$\Pi_N^{\text{F}^{\text{weak (NI)}}} = \left[\frac{a}{3}\right]^2 - F \quad \text{and} \quad \Pi_S^{\text{F}^{\text{weak(NI)}}} = \left[\frac{a}{3}\right]^2. \tag{12}$$

However, if firm *S* innovates, the equilibrium outputs of firms *N* and *S* are respectively $x_N^{F^{\text{weak (I)}}} = \frac{1}{3}\frac{a}{(1+\gamma)}$, $x_S^{F^{\text{weak (I)}}} = \frac{1}{3}\frac{a}{(1+\gamma)}$, $y_N^{F^{\text{weak (I)}}} = \frac{1}{3}\frac{a}{(1+\gamma)}$ and $y_S^{F^{\text{weak (I)}}} = \frac{1}{3}\frac{a}{(1+\gamma)}$. The equilibrium profits of the firms are

$$\Pi_N^{\text{F}^{\text{weal (I)}}} = \frac{2a^2}{9(1+\gamma)} - F \quad \text{and} \quad \Pi_S^{\text{F}^{\text{weak (I)}}} = \frac{2a^2}{9(1+\gamma)} - R. \tag{13}$$

Therefore, if there is a weak patent protection in the Southern country and firm *N* undertakes FDI, firm S innovates if

$$R < \frac{2}{9}\frac{a^2}{(1+\gamma)} - \frac{a^2}{9} \equiv R_{FDI}^{\text{weak}}. \tag{14}$$

The following result follows immediately from (11) and (14).

Lemma 2: $R_{FDI}^{weak} < R_{Export}^{weak}$.

Lemmas 1 and 2 show that, for a given Southern patent regime, the incentive for innovation by firm *S* is higher under export (compared to FDI) by firm *N*. Since export by the Northern firm involves transportation cost, the equilibrium output of firm *S* is

higher under export than under FDI by firm *N*, which increases the Southern firm's gain from innovation under export compared to FDI by firm *N*. This is in line with the empirical evidence (Veugelers and Houte, 1990 and Goto and Odagiri, 2003), and poses an interesting question on whether inward FDI would always be conducive to technological improvement in the host country.

Now we are in position to determine firm *S*'s incentive for innovation depending on the Southern patent regime and the plant location decision of firm *N*.

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

Proof: See Appendix A for the proof.

Proposition 1 shows that the Southern firm has lower incentive for innovation under weak patent protection than under strong patent protection. A stronger patent protection helps to increase the incentive for innovation by firm *S* in two ways. On the one hand, a stronger Southern patent regime increases the profit of firm *S* under innovation by protecting its product from knowledge spillover. This is similar to the usual R&D inducing effect of a stronger patent protection. On the other hand, a stronger Southern patent regime reduces firm *S*'s profit under no innovation by eliminating knowledge spillover, thus increasing its gain from innovation.

4. Export or FDI?

Now we determine the equilibrium plant location decision of firm *N*. Firm *N* prefers FDI to export if $\Pi_N^F > \Pi_N^E$. However, previous section shows that whether firm *S* innovates or not may depend on firm *N*'s decision on export and FDI. Hence, firm *N*'s

plant location decision should internalize the R&D decision of firm *S*. As a result, we consider the following cases.

(i) $R_{Export}^{\text{strong}} < R$, which implies that firm *S* does not innovate irrespective of the plant location decision of firm *N* and the patent regime in the South. This is similar to the previous works where firm *S* is not an innovator. This case creates the benchmark for our analysis.

(ii) $R < R_{FDI}^{weak}$, which is in contrast to case (i) and considers another extreme situation where *S* innovates irrespective of the plant location decision of firm *N* and the patent regime in the South.

(iii) $R_{FDI}^{\text{weak}} < R < R_{Export}^{\text{weak}}$, which implies that firm *S* does not innovate if the Southern patent protection is weak and firm *N* undertakes FDI.

(iv) $R_{Export}^{\text{weak}} < R < R_{FDI}^{\text{strong}}$, which implies that firm *S* innovates only under a stronger Southern patent regime.

(v) $R_{FDI}^{\text{strong}} < R < R_{Export}^{\text{strong}}$, which implies that firm *S* innovates under a stronger Southern patent regime provided firm *N* exports.

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

First, consider the case where the R&D cost of firm *S* is so high that it does not innovate irrespective of the Southern patent regime and the plant location decision of firm *N*. This case corresponds to the previous works where the Southern firm can only imitate the product of the Northern firm, thus creating the benchmark for our analysis.

Proposition 2: *If the cost of innovation is such that* $R_{Export}^{\text{strong}} < R$*, firm N's incentive for FDI is higher under strong patent protection in the South for all feasible values of* t and γ.

Proof: See Appendix B for the proof.

The above result is due to the standard argument for a stronger Southern patent protection. If firm *S* never innovates, a stronger Southern patent protection increases firm *N*'s incentive for innovation by preventing imitation by firm S.

4.2. If $R < R_{FDI}^{weak}$

In contrast to the previous subsection, where firm *S* never innovates, we now consider the other extreme case where the R&D cost of firm *S* is so small that it innovates irrespective of the Southern patent regime and the mode of production of firm *N*.

Proposition 3: *If the cost of innovation is small enough (i.e.,* $R < R_{FDI}^{weak}$*), firm N's incentive for FDI is higher under a stronger Southern patent regime if* $t > \hat{t} \equiv a(2-\gamma)\dfrac{6\gamma+2\gamma^2+7}{23+14\gamma-2\gamma^2-2\gamma^3}$ *and* $\gamma > \hat{\gamma} \approx 0.753$*. Otherwise, firm N's incentive for FDI is higher under a weaker Southern patent regime.*

Proof: See Appendix C for the proof.

The difference between Propositions 2 and 3 is attributable to innovation by firm S. Innovation (compared to no innovation) by firm *S* has two opposing effects on firm *N*. On the one hand, innovation by firm *S* reduces firm *N*'s profit under a stronger Southern patent regime by creating product-market competition. On the other hand,

innovation by firm *S* increases firm *N*'s profit under a weak Southern patent regime by increasing its product range due to knowledge spillover. Although these effects are true under both export and FDI by firm *N*, whether innovation by firm *S* reduces firm *N*'s incentive for FDI under a stronger Southern patent regime depends on the degree of product differentiation and transportation cost. Firm *N*'s incentive for FDI is higher under a weak Southern patent regime if either product differentiation is sufficiently large (i.e., γ is sufficiently small) or the transportation cost is sufficiently small (i.e., t is sufficiently small).

If the products are sufficiently differentiated, innovation by firm *S* does not create significant competition for firm *N*. Hence, innovation by firm *S* does not affect the profit of firm *N* significantly under a strong Southern patent regime. However, innovation by firm *S* helps to increase the profit of firm *N* significantly under a weak Southern patent regime, by increasing its product range through knowledge spillover. This profit gain for firm *N* is higher under FDI compared to export, because of the output distortion created by the transportation cost under export. Hence, in the presence of innovation by firm *S*, a weaker Southern patent regime increases firm *N*'s incentive for FDI if the products are sufficiently differentiated.

If the products are not very much differentiated, Southern innovation creates significant product-market competition under the strong Southern patent regime. However, because the products are not very much differentiated, the intensity of the product-market competition following Southern innovation remains very much similar under the weak and strong Southern patent regimes. Further, if the transportation cost is small, the profit of firm *N* is very much similar under FDI and export, irrespective of the Southern patent regime. Therefore, if the products are not very much differentiated and the transportation cost is very small, firm *N*'s profit difference between FDI and export

is very much similar under the different Southern patent regimes. However, knowledge spillover under a weak Southern patent regime allows firm *N* to produce more products compared to a strong Southern patent regime, thus increasing firm *N*'s incentive for FDI under a weak Southern patent regime compared to a strong Southern patent regime by increasing its profit difference between FDI and export.

If the products are not very much differentiated but the transportation cost is high, the transportation cost distorts the output of firm *N* significantly under export. However, because of a relatively higher product-market competition (or a relatively lower market share) under a weak Southern patent regime compared to a strong Southern patent regime, firm *N*'s loss of profit under export from a higher transportation cost is lower under the former patent regime compared to the latter patent regime. Hence, if the transportation cost is sufficiently high, firm *N*'s incentive for FDI is higher under a stronger Southern patent regime if the products are not very much differentiated.

4.3. If $R_{\text{FDI}}^{\text{weak}} < R < R_{\text{Export}}^{\text{weak}}$

Now consider the case where the R&D cost of firm *S* is such that it does not innovate under the weak Southern patent regime if firm *N* undertakes FDI but innovates otherwise.

Proposition 4: *If the cost of innovation is such that* $R_{\text{FDI}}^{\text{weak}} < R < R_{\text{Export}}^{\text{weak}}$, *firm N's incentive for FDI is higher under a stronger Southern patent regime.*

Proof: See Appendix D for the proof.

The above result along with Proposition 3 suggests that if the cost of Southern innovation is relatively high so that firm *S* does not innovate when there is a weak Southern patent protection and firm *N* does FDI, firm *N*'s incentive for FDI under a stronger Southern patent regime increases compared to a situation where firm *S* always innovates. If the Southern patent protection is weak and firm *S* does not innovate under FDI by firm *N*, firm *N*'s profit under FDI in the case of a weak Southern patent protection reduces compared to the situation where firm *S* innovates under FDI by firm *N*. This happens since no innovation by firm *S* reduces the product range of firm *N*. This loss of profit of firm *N* from FDI under the weak Southern patent regime increases firm *N*'s incentive for FDI under the stronger Southern patent regime.

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

Now consider the situation where the R&D cost of firm *S* is such that it innovates only under a stronger Southern patent regime, irrespective of exporting or FDI by firm *N*.

Proposition 5: *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* $\gamma < \frac{\sqrt{13}-3}{2}$ *or* $\gamma > \frac{\sqrt{13}-3}{2}$ *and* $t > \tilde{t} \equiv a\frac{(2-\gamma)\left(3\gamma+\gamma^2-1\right)}{(\gamma+1)\left(7-\gamma^2\right)}$.

Proof: See Appendix E for the proof.

Proposition 5 can be explained as follows. Strong patent protection in the South eliminates knowledge spillover 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 compared to the weak Southern patent protection, since product differentiation is

higher under the former patent regime than the latter patent regime. If the products are sufficiently differentiated, the profit gain for firm *N* under a strong patent regime (compared with the weak patent regime) is higher under FDI compared to exporting, because of the output distortion under export created by the transportation cost. However, if the products are not very much differentiated, firm *N*'s profit gain under the strong patent protection is higher under FDI compared to export provided export creates significant output distortion, which happens for a sufficiently high transportation cost. Therefore, if the products are not very much differentiated and the transportation cost is sufficiently small, firm *N*'s profit gain under a stronger patent regime is higher under export compared to FDI, thus creating higher FDI incentive under a weaker Southern patent regime.

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

Finally, we consider the case where the R&D cost of firm S is such that it innovates only if firm *N* exports and there is strong patent protection in the South.

Proposition 6: *If the cost of innovation is such that* $R_{\text{FDI}}^{\text{strong}} < R < R_{\text{Export}}^{\text{strong}}$, *firm N's incentive for FDI is higher under strong patent protection in the South* for *all feasible values of t* and γ.

Proof: See Appendix F for the proof.

Intuitively, the above result can be explained as follows. As usual, a stronger Southern patent regime helps to protect the product of firm *N*, which creates an incentive for FDI. Moreover, since firm *S* innovates only if there is strong southern patent protection and firm *N* exports, FDI by firm *N* under the strong Southern patent

protection eliminates product market competition by deterring Southern innovation, thus encouraging firm *N* to undertake FDI under a stronger Southern patent regime.

The following table summarizes above findings.

R	**$F^{strong} - F^{weak} > 0$ for**
$R_{\text{Export}}^{\text{strong}} < R$	$t > 0, \gamma > 0$
$R_{\text{FDI}}^{\text{strong}} < R < R_{\text{Export}}^{\text{strong}}$	$t > 0, \gamma > 0$
$R_{\text{Export}}^{\text{weak}} < R < R_{\text{FDI}}^{\text{strong}}$	$\gamma < \frac{\sqrt{13}-3}{2}$ *or* $\gamma > \frac{\sqrt{13}-3}{2}$ *and* $t > \tilde{t} \equiv a\frac{(2-\gamma)(3\gamma+\gamma^2-1)}{(\gamma+1)(7-\gamma^2)}$
$R_{\text{FDI}}^{\text{weak}} < R < R_{\text{Export}}^{\text{weak}}$	$t > 0, \gamma > 0$
$R < R_{FDI}^{weak}$	$t > \hat{t} \equiv a(2-\gamma)\frac{6\gamma+2\gamma^2+7}{23+14\gamma-2\gamma^2-2\gamma^3}$ and $\gamma > \hat{\gamma} \approx 0.753$

5. Remarks

5.1. Market demand in the North

We have considered that the demand for the product is only in the Southern market. Alternatively, we may consider that the above analysis assumes that the Northern demand for the product is very small. Relaxing the assumption of market demand only in the South will not alter our above results as long as the Southern firm serves only the Southern market, which may be due to the financial constraint faced by the Southern firm. As mentioned in the literature, export to other countries involves significant cost (Das et al., 2007), and the financial constraint of the Southern firm may prevent it from exporting to the Northern market.

If there is demand in both the markets and firm *S* can export to the Northern market, it can be seen easily that it will give the Northern firm further incentive for FDI under a stronger Southern patent regime. If there is demand in the Northern market, it will increase the Southern firm's incentive for innovation by increasing its benefit from innovation, irrespective of the Southern patent regime.[11] If there is a strong patent protection in the South, the Southern firm does not get any profit without innovation, while, under a weak Southern patent protection, the Southern firm gets a positive profit due to knowledge spillover, even if it does not innovate. As a result, even with the existence of a Northern market, the Southern firm's incentive for innovation remains higher under a strong Southern patent protection than under a weak Southern patent protection.

However, the existence of a Northern market may increase the Northern firm's incentive for FDI compared to the situation with no Northern demand. If there is a Northern market, the Northern firm's strategy should be designed also to protect its Northern profit. The profit in the Northern market can be affected if the Southern firm does innovation, because, the Southern firm cannot enter the Northern market without innovation. Hence, the Northern firm should choose its production strategy to protect its Northern profit. Since the Southern firm's incentive for innovation increases with a stronger Southern patent regime but reduces with FDI by the Northern firm, the existence of Northern market will give the Northern firm further incentive for FDI under a stronger patent regime. However, unless this effect of the Northern market on the Northern firm's incentive for FDI is not very strong, we still get situations, as shown in the above analysis, that the Northern firm's incentive for FDI can be higher under a weaker Southern patent regime.

[11] Patent protection in the North is assumed to be strong.

5.2. R&D investment affecting the degree of product differentiation

To show our results in the simplest way, we have assumed that the degree of product differentiation is not affected by the R&D investment. However, it is quite possible to visualize a situation where the Southern firm not only innovates a new product, but it can also increase the degree of product differentiation by investing more in R&D. In this situation, the optimal R&D investment will depend on the Southern firm's net marginal profit from innovation, which is given by the difference between its marginal benefit from R&D and the marginal cost of R&D. It is intuitive to argue that if the slope of the Southern firm's marginal cost of R&D is very high, it reduces the Southern firm's marginal profit from R&D, thus creating a lower amount of R&D investment and lower degree of product differentiation. In this situation, one might expect results similar to our analysis with a lower cost of R&D (since lower R&D investment implies a lower cost of R&D) and lower degree of product differentiation. On the other hand, if the slope of the Southern firm's marginal cost on R&D is very low, the optimal R&D investment and therefore, the degree of product differentiation will be very high. In this situation, we might expect results similar to our results with a relatively high R&D cost (since higher R&D investments imply higher R&D costs) and higher degree of product differentiation.

6. Conclusion

Though evidence suggests considerable innovative activities by the Southern firms, the literature on patent protection did not pay attention to these activities in determining the effects of Southern patent regime on inward FDI. We take up this issue here. In a model of international oligopoly, we show that the effect of Southern patent protection on FDI

by the Northern firm depends on the Southern firm's innovative capability, the degree of product differentiation and the transportation cost. If either the cost of Southern innovation is sufficiently low such that the Southern firm innovates irrespective of the Southern patent regime or the Southern firm's cost of innovation is moderate such that it innovates only under a stronger Southern patent regime, a stronger Southern patent regime may reduce the Northern firm's incentive for FDI. For other costs of Southern innovation, a stronger Southern patent regime increases the Northern firm's incentive for FDI.

An important policy implication resulting from our paper is that, in this era of globalization, Southern countries may need to consider the trade-off between attracting FDI and encouraging domestic innovation while designing their patent policies. There are situations where a strong patent protection increases domestic innovation, yet deters FDI. Hence, along with patent protection, Southern countries may need to increase the attractiveness of FDI through complementary policies.

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 Southern firms innovate, the Northern firm may have higher FDI incentive under a weaker Southern patent regime, since a weaker patent protection helps to increase the product range of the Northen firm and FDI helps to reduce the output distortion from 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 a stronger Southern patent regime increases, since it 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 may also important to identify the effects of the patent regimes on two-way FDIs where the Southern firms can also undertake FDI with demand in the North also. It would also be interesting to focus on patent harmonization in this respect. We intend to take up these issues in our future research.

Appendix

A Proof of Proposition 1

We get from (39) and (38) that $\frac{\partial(R_{FDI}^{strong} - R_{Export}^{weak})}{\partial t} = -\frac{2(1-\gamma)(a+t)}{9(1+\gamma)} < 0$. Hence, $R_{FDI}^{\text{strong}} - R_{Export}^{\text{weak}}$ reaches minimum at $t = \frac{a}{2}$, and the minimum value of $R_{FDI}^{\text{strong}} - R_{Export}^{\text{weak}} = \frac{1}{4}a^2\gamma\frac{3\gamma+\gamma^2+4}{(\gamma+1)(\gamma+2)^2} > 0$, which proves that $R_{FDI}^{\text{strong}} > R_{Export}^{\text{weak}}$.

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

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

Taken together, we get that $R_{FDI}^{\text{Process}} < R_{Export}^{\text{Process}} < R_{FDI}^{\text{Product}} < R_{Export}^{\text{Product}}$. ■

B Proof of Proposition 2

Consider $R_{\text{Export}}^{\text{strong}} < R$. Under a weak Southern patent protection, it follows from (9) and (12) that firm *N* prefers FDI to export for $F < F_1^{\text{weak (NI)}} = \frac{a^2}{9} - \frac{(a-2t)^2}{9}$.

However, under a stronger Southern patent regime, it follows from (3) and (6) that firm *N* prefers FDI to export for $F < F_2^{\text{strong (NI)}} \equiv \left(\frac{a}{2}\right)^2 - \left(\frac{a-t}{2}\right)^2$.

We get that $F_2^{strong(NI)} > F_1^{weak(NI)}$, which proves the result. ■

C Proof of Proposition 3

Consider $R < R_{FDI}^{weak}$. Under a weak Southern patent protection, it follows from (10) and (13) that firm *N* prefers FDI to export for $F < F_3^{\text{weak (I)}} \equiv \frac{2a^2}{9(1+\gamma)} - \frac{2(a-2t)^2}{9(1+\gamma)}$.

However, if the Southern patent regime is strong, it follows from (4) and (7) that firm *N* prefers FDI to export for $F < F_4^{\text{strong (I)}} \equiv \left(\frac{a}{2+\gamma}\right)^2 - \left(\frac{a(2-\gamma)-2t}{4-\gamma^2}\right)^2$.

We get that $F_4^{\text{strong (I)}} > F_3^{weak(I)}$ if $t > \hat{t} \equiv a(2-\gamma)\frac{6\gamma+2\gamma^2+7}{23+14\gamma-2\gamma^2-2\gamma^3}$. 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. ■

D Proof of Proposition 4

Consider $R_{\text{FDI}}^{\text{weak}} < R < R_{\text{Export}}^{\text{weak}}$. Under a weak Southern patent protection, it follows from (10) and (12) that firm *N* prefers FDI to export for $F < F_5^{\text{weak (NI)}} \equiv \left(\frac{a}{3}\right)^2 - \frac{2(a-2t)^2}{9(1+\gamma)}$.

However, under a stronger Southern patent regime, it follows from (4) and (7) that firm *N* prefers FDI to export for $F < F_4^{\text{strong (I)}} \equiv \left(\frac{a}{2+\gamma}\right)^2 - \left(\frac{a(2-\gamma)-2t}{4-\gamma^2}\right)^2$.

Setting $F_4^{strong(I)} = F_5^{weak(NI)}$, we get the following two roots of t:

$$\frac{a(14+5\gamma-2\gamma^2-2\gamma^3-(-2+\gamma)\sqrt{-43-64\gamma-7\gamma^2+26\gamma^3+14\gamma^4+2\gamma^5})}{2(23+14\gamma-2\gamma^2-2\gamma^3)}$$

$$\frac{a(14a+5\gamma-2\gamma^2-2\gamma^3+(-2+\gamma)\sqrt{-43-64\gamma-7\gamma^2+26\gamma^3+14\gamma^4+2\gamma^5})}{2(23+14\gamma-2\gamma^2-2\gamma^3)}.$$

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 γ. Hence, there is no real value of t such that $F_4^{strong(I)}=F_5^{weak(NI)}$.

Now take a value of γ, say $\gamma=0$. We get that $F_4^{strong(I)}>F_5^{weak(NI)}$ if $\gamma=0$. Hence, for any a, t and γ, we get $F_4^{strong(I)}>F_5^{weak(NI)}$, which implies that firm *N*'s incentive for FDI is higher under strong patent protection. ■

E Proof of Proposition 5

Consider $R_{\text{Export}}^{\text{weak}}<R<R_{\text{FDI}}^{\text{strong}}$. Under a weak Southern patent regime, it follows from (4) and (9) that firm *N* prefers FDI to export for $F<F_1^{\text{weak (NI)}}=\frac{a^2}{9}-\frac{(a-2t)^2}{9}$.

However, under a stronger Southern patent regime, it follows from (4) and (7) that firm *N* prefers FDI to export for $F<F_4^{\text{strong (I)}}\equiv\left(\frac{a}{2+\gamma}\right)^2-\left(\frac{a(2-\gamma)-2t}{4-\gamma^2}\right)^2$.

We get that

$$F_4^{strong(I)}-F_1^{weak(NI)}=\frac{a^2}{(2+\gamma)^2}-\frac{(a(2-\gamma)-2t)^2}{(4-\gamma^2)^2}-\frac{a^2}{9}+\frac{(a-2t)^2}{9}>0$$

if $t>\tilde{t}\equiv a\frac{(2-\gamma)(3\gamma+\gamma^2-1)}{(\gamma+1)(7-\gamma^2)}$, where $\tilde{t}<t_{\max}=\frac{a}{2}$. However, $\tilde{t}>0$ provided $\gamma>\frac{\sqrt{13}-3}{2}$. Therefore, firm *N*'s incentive for FDI is higher under a stronger

Southern patent regime if either $\gamma < \frac{\sqrt{13}-3}{2}$ so that $t > 0$ is always greater than $\tilde{t}$, or $\gamma > \frac{\sqrt{13}-3}{2}$ and $t > \tilde{t}$. ■

F Proof of Proposition 6

Consider $R_{\text{FDI}}^{\text{strong}} < R < R_{\text{Export}}^{\text{strong}}$. Under a weak Southern patent regime, it follows from (9) and (12) that firm *N* prefers FDI to export for $F < F_1^{\text{weak (NI)}} = \frac{a^2}{9} - \frac{(a-2t)^2}{9}$.

However, under a stronger Southern patent regime, it follows from (4) and (6) that firm *N* prefers FDI to export for $F < F_6^{\text{strong (NI)}} \equiv \left(\frac{a}{2}\right)^2 - \left(\frac{a(2-\gamma)-2t}{4-\gamma^2}\right)^2$.

We get that $F_6^{\text{strong(NI)}} > F_2^{\text{strong(NI)}}$ as $\left(\frac{a-t}{2}\right)^2 - \left(\frac{a(2-\gamma)-2t}{4-\gamma^2}\right)^2 \geq 0$ for $\gamma \in [0,1)$. Further, we get that $F_2^{\text{strong(NI)}} > F_1^{\text{weak(NI)}}$. Thus, it proves that $F_6^{\text{strong(NI)}} > F_1^{\text{weak(NI)}}$. ■

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