Patent protection and Southern innovation: a strategic analysis[†]

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Abstract: In this paper, we argue that patent protection in the South may encourage the Southern firms to innovate new products, which compete with the existing products of the Northern firms in the world market. Thus, strengthening patent protection in the South may make the Northern firms worse off. Further, strengthening patent protection in the South may make the Southern firms better off by increasing their returns from innovation. Our welfare analysis shows that the impact of Southern patent protection on welfare of a country or the world depends on the cost of Southern innovation and the degree of product substitutability. We also provide some interesting insights into the outcome of international negotiation on Southern patent protection.

Key Words: Patent protection; North-South trade; Welfare

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1. Introduction

It is generally believed that lack of an effective patent system in the developing (Southern) countries allow the Southern firms to imitate technologies of the developed (Northern) country firms, thus reducing the Northern firms' returns from innovation and thereby an argument is made for strengthening Southern patent system. On the basis of this conventional wisdom, it is mandated under the current WTO (World Trade Organization) regime that the member countries must adopt and enforce strong, non-discriminatory minimum standard of intellectual property rights (IPRs) protection.

The theoretical literature, however, does not support the universal patent protection for higher welfare in the world. For example, Deardorff (1992) argued for a case of limiting patent protection geographically rather than extending it universally across the world. Chin and Grossman (1990) studied the welfare implications of patent protection in a North-South trading environment and found that global welfare might go up or down depending on the productivity of Northern R&D. Diwan and Rodrik (1991) have also shown that increased patent protection in the South may not be good for the North. Other papers which analyze the effects of stronger Southern patent systems in a North-South trading environment include Segerstrom *et al*. (1990), Grossman and Helpman (1991), Helpman (1993), Taylor (1994), Vishwasrao (1994), Lai (1998), Fosfuri (2000), Markusen (2001), Glass and Saggi (2002), Sinha (2006), and Benchekroun and Vishwasrao (2008), to name a few.

A common feature of the above-mentioned works is to consider no innovation by the Southern firms. However, empirical facts reflect that it is not necessarily the case for many developing and newly industrialized countries. Significant amount of R&D activities can be found in many Asian countries such as South Korea, India, China and Taiwan. 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 R&D efforts are evidenced in Indian pharmaceutical industry (The Financial Express, December 13, 2004).[1] Tsai and Wang (2004) provide evidence of significant R&D activities in Taiwan's electronics industry. Wei et al. (2008) provide the evidence of innovation by Chinese motorcycle companies. The importance of innovation in the less developed countries is also acknowledged in Muniagurria and Singh (1997), Zhou et al. (2002) and Chen and Puttitanun (2005).

Under this backdrop, with the help of an intra-industry trade model we argue that strengthening Southern patent system may not be justified on many grounds. First, it may not maximize the world welfare. Second, the conventional argument for imposing patent protection in the South for helping the Northern firms or Northern country may not hold when Southern firm can also innovate. In other words, the conventional argument in favor of the North typically ignores the competition effect from the South under a stronger Southern patent regime. Third, under certain conditions, the absence of Southern patent protection may serve the interests of all parties concerned.

We show that patent protection in the South increases the Southern firm's incentive for inventing new products,[2] thus allowing them to compete with the Northern firms in the world market. Hence, patent protection in the South not necessarily reduces competition faced by the Northern firms. It may only shift the market where the Northern firms face competition from the Southern firms. If there is no Southern patent protection, the Northern firms face competition in the Southern market, while patent protection in the South may protect the Northern firm's Southern market, yet they may face competition in the Northern

[1] 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".

[2] Empirical evidences are in conformity with this result. For example, the report by "Chemtech Foundation" shows that, in 2003, the average R&D expenditure by Indian Pharma industry is around 2% of the turnover as compared to global average of 15%. However, with the imposition of a stronger Indian patent system, R&D expenditure of major players is expected to touch 5% of their turnover by 2005.

market.[3] We show that if the cost of Southern innovation is not very small, the Northern firm is better off under no Southern patent protection if the products are not very much differentiated. We also show that if the cost of Southern innovation is small, Southern patent protection may make the Southern firm better off.

Our welfare analysis shows that Southern patent protection may make the Southern country better off, thus contradicting the common skepticism about lower Southern welfare following patent protection in the South. Our argument for welfare improving effect of Southern patent protection is very different from the existing argument suggesting that Southern patent protection makes the Southern country better off by increasing Northern innovation. In contrast, we show that innovation by the Southern firm and its penetration into the Northern market increase Southern welfare following the imposition of patent protection in the South. We find that, in both the North and the South, there may be conflicting interests between the firms and the society for strengthening Southern patent system. Whether Southern patent protection increases welfare of a specific country or the world welfare in general depends on the Southern cost of innovation and the degree of product differentiation. Given the conflict of interests between different parties, we examine whether a compensation package can be designed for resolving the conflict through international negotiation. We show that if the Southern patent system does not affect the incentive for Southern innovation, North cannot compensate the South for its welfare loss following Southern patent protection. However, if Southern patent protection induces Southern innovation, under certain conditions, a suitable compensation scheme can be designed to compensate the South for its welfare loss due to patent protection in the South. Thus, we provide important insights on the possible outcome of international negotiation in the context of patent enforcement in the southern countries.

[3] One should not take the literal meaning of the term "no patent protection". By "no patent protection", we simply mean an ineffective patent protection, which fails to protect the patent holders from imitators. It is also not our intention to assert that "patent protection" in the South can always provide complete protection to the patent holders, though, for simplicity, our analysis will consider that patent protection eliminates the threat of imitation completely.

The remainder of the paper is organized as follows. Section 2 presents the basic model. Section 3 analyzes the market structure and the resultant profits depending on the Southern patent system. Section 4 considers welfare implications of Southern patent protection. While, for simplicity, we assume perfect imitation and zero cost of imitation for our basic analysis, we discuss the implications of costly and imperfect imitation in Section 5. Section 6 concludes. Proofs are relegated to the appendices.

2. The model

Consider two countries, called North and South, with separated markets. 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 technology for a new product. However, they can also imitate the technology invented by the other firm, if the patent law permits.

While we always maintain patent protection in the North, we consider two regimes in the South: no patent protection and patent protection. We assume that patent protection in the North allows only the patent holder to sell its product in the Northern market, thus preventing any imitator to enter the Northern market. The situation will be similar in the South under Southern patent protection. However, under no Southern patent protection, both firms are allowed to do non-infringing imitation of the competitor's technology and can sell the same product in the South.[4]

At this point, it is worth mentioning that even if imitation by the Southern firms is a well known phenomenon, recent evidence suggests that Southern innovating firms may also face the threat of imitation from (or knowledge spillover to) the Northern firms. Recent case studies on Chinese firms indicate that foreign and local firms learn and imitate from each

[4] As already mentioned, complete elimination of the threat of imitation under patent protection is for simplicity. Imitation creates a perfect substitute of the original product is also for simplicity. Our formulation is a simple way to capture the idea that patent protection reduces the possibility of imitation, which is likely to create a relatively close substitutable products compared to a situation where the firms invent different products.

other (Wei et al., 2008). CEO of a Chinese firm surveyed in Wei et al. (2008) says "There are more than 3,000 firms producing components and parts for the motorcycle industry in Chongqing. While supplying my company, such a firm may supply my foreign and local competitors at the same time. Competitors may well obtain my company's most advanced technology or method via the supplier. For instance, in 2003, my company invented a new technology for motorcycle shock absorption. Within 2 months foreign and local competitors produced a very similar, almost identical, product." Econometric analysis of Wei et al. (2008) also shows positive relationship between R&D activities in the Chinese firms and productivity in the foreign firms.

We consider the following three-stage game. At stage 1, the firms take R&D decisions. We assume that firm *N* targets to invent product *x*, while firm *S* targets to invent product *y*, which is an imperfect substitute of *x*. We assume that each firm can invent a single product at one point of time, which implies a restriction on the R&D capacity.[5] Since *x* and *y* are imperfect substitutes, it should be clear that each firm has the incentive to invent a different technology.[6] At stage 2, if the patent law permits, each firm decides whether to imitate the technology of the competitor. At stage 3, the firms compete in the product market like Cournot duopolists. We solve the game through backward induction.

Assume that the Northern firm is more capable in doing R&D and therefore, it requires lower R&D investment. We assume that the R&D investment of the Northern firm is $F_N \geq 0$ and the Southern firm needs to spend F amount more than the Northern firm, where $F > 0$. So, the R&D investment of the Southern firm is $F_S = F_N + F$. This is consistent with the previous works where the firms in the developed countries do R&D at a lower cost

[5] In real world, we don't find one firm 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 about the product choice, i.e., which firm will invent which product. However, the flow of information at the R&D stage and slight early investment of one firm may solve this coordination problem. For simplicity, we assume away this coordination problem, as it does not add anything to the main purpose of this paper.

(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 notations, we normalize firm *N*'s cost of R&D to 0, i.e., $F_N = 0$.[7]

We assume that both firms are symmetric with respect to imitation. To make imitation always profitable to both firms, whenever it is permitted by the patent law, we assume for simplicity that imitation is costless and perfect. We will discuss the implications of costly and imperfect imitation in section 5.

Consider the following demand structure in each country. We assume that the representative consumer's utility is $U(x,y)+m$ with U(x, y) = $a(x+y)-\frac{x^2}{2}-\frac{y^2}{2}-\gamma xy$, where *m* is the numeraire good and $\gamma \in [0,1]$ is the degree of product differentiation.[8] If $\gamma = 0$, the products are isolated but for $\gamma = 1$, the products are perfect substitutes. Since we consider the goods x and y as different, we focus on $\gamma \in [0,1)$.

Given the utility function, the inverse market demand functions for x and y in each of the North and the South are respectively

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

$$P_y = a - y - \gamma x, \tag{2}$$

where P_x and P_y are the prices of *x* and *y*. We assume that the constant average costs of production for both x and y are c, with $c < a$, and they are the same for both firms.

3. Implications for the profits

3.1. Patent protection in the South

[7] This assumption does not affect our qualitative results as long as firm *N* always innovates in equilibrium, which we consider throughout our analysis. However, it should be remembered that, even if firm *N* always invents product *x*, the diseconomies in the R&D process or financial constraint prevents it from inventing both *x* and *y*.

[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.

Under patent protection in the South, imitation is not an option to the firms. So, if firm *S* invents *y*, the firms compete like Cournot duopolists in both the North and the South. The outputs of *x* and *y* in each country is $\frac{(a-c)}{(2+\gamma)}$. The profits of the firms are

$$\pi_N^P = \frac{2(a-c)^2}{(2+\gamma)^2} \qquad \text{and} \qquad \pi_S^P = \frac{2(a-c)^2}{(2+\gamma)^2} - F_S . \tag{3}$$

3.2. No patent protection in the South

If there is no patent protection in the South, the firms can sell a product in the South even with imitated technologies. After the R&D decision at stage 1, the firms decide on imitation at stage 2. Since the cost of imitation is normalized to zero, it is easy to check that, at stage 2, each firm finds it profitable to imitate the technology of the other firm, in case the other firm has invented the technology at stage 1.[9]

Now we analyze stage 1 of the game. Note that our assumption about the R&D costs implies that firm *N* always innovates *x*. Hence, the R&D decision is effectively for firm *S*. Knowing that firm *N* innovates *x* and imitation is profitable at stage 2, firm *S* has two strategies at stage 1: (i) innovate *y* and imitate *x* at stage 2 (IR) and (ii) don't innovate *y* and imitate *x* at stage 2 (OI). Under IR, firm *S* sells both products in the South and only *y* in the North. Under OI, firm *S* sells only *x* in the South and nothing in the North.

If firm *S* adopts the strategy IR, the firms compete in both the North and the South. In the North, firm *N* sells x and firm *S* sells y. However, each firm sells both *x* and *y* in the South. The amount of x and y sold in the North is $\frac{(a-c)}{(2+\gamma)}$ and each firm sells $\frac{(a-c)}{3(1+\gamma)}$ units of each good in the South. The profits of the firms are

$$\pi_N^{IR} = \frac{2(a-c)^2}{9(1+\gamma)} + \frac{(a-c)^2}{(2+\gamma)^2} \qquad \text{and} \qquad \pi_S^{IR} = \frac{2(a-c)^2}{9(1+\gamma)} + \frac{(a-c)^2}{(2+\gamma)^2} - F_S . \tag{4}$$

[9] The logic follows from Eswaran (1994).

If firm *S* adopts the strategy OI, firm *N* sells as a monopolist in the North. However, both firms sell x in the South. The equilibrium output in the North is $\frac{(a-c)}{2}$, and each firm sells $\frac{(a-c)}{3}$ units of x in the South. The profits of the firms are

$$\pi_N^{OI} = \frac{(a-c)^2}{9} + \frac{(a-c)^2}{4} \qquad \text{and} \qquad \pi_S^{OI} = \frac{(a-c)^2}{9}. \tag{5}$$

It follows from (4) and (5) that firm *S* chooses OI instead of IR if

$$F_S \geq (a-c)^2\left[\frac{(1-\gamma)}{9(1+\gamma)} + \frac{1}{(2+\gamma)^2}\right] = G \tag{6}$$

where $G > 0$. Hence, the profits of the firms under no Southern patent protection are given by (4) for $F_S < G$ and by (5) for $F_S \geq G$. We restrict the value of F_S with an upper limit $\overline{F}_S$ such that at $\overline{F}_S$, $\pi_S^{PDP} = 0$. It follows from (3) that $\overline{F}_S \equiv \frac{2(a-c)^2}{(2+\gamma)^2}$.

By comparing the payoffs of the firms, we find the following preference of the firms over the Southern patent regime.

Proposition 1: *(i) If the cost of Southern innovation is small, i.e., $F_S < G$, both firms prefer patent protection in the South.*

(ii) If the cost of Southern innovation is moderate, i.e., $F_S \in [G, H)$, where $H \equiv \frac{2(a-c)^2}{(2+\gamma)^2} - \frac{(a-c)^2}{9}$, firm S prefers patent protection in the South, while firm N prefers no patent protection (patent protection) in the South for $\gamma > (<)\gamma^c (= .35$, approx.).

(iii) If Southern innovation is very costly, i.e., $F_S \in [H, \overline{F}_S)$, firm S prefers no patent protection in the South, while firm N prefers no patent protection (patent protection) in the South for $\gamma > (<)\gamma^c$.

Proof: See Appendix A.

Figure 1 provides a graphical representation of the above proposition.

[Figure 1 about here]

The intuition for the above proposition is as follows. Note that the underlying market structures for different Southern costs of innovation are the crucial factor behind the above preference of the firms. Imitation is not an option under Southern patent protection, and both firms invent for $F < \overline{F}_s$. However, imitation is a feasible option under no Southern patent protection and firm *S* may not have the incentive for innovation even for $F < \overline{F}_s$.

If the cost of Southern innovation is small ($F_S < G$) and there is no patent protection in the South, each firm innovates a new technology and imitates the technology of the competitor. This threat of imitation significantly reduces both firms' returns from innovation and makes both firms better off under Southern patent protection.

If the cost of Southern innovation is moderate ($F_S \in [G, H)$), firm *S* innovates under Southern patent protection, while it only imitates if there is no patent protection in the South. Since imitation is not an option under Southern patent protection, firm *S* innovates in this situation for earning positive profits. However, no Southern patent protection reduces firm *S*'s incentive for innovation compared to the situation with Southern patent protection since imitation provides positive profits to firm S, thus increasing firm *S*'s profit under no innovation. Even if Southern patent protection encourages firm *S* to undertake costly innovation, no imitation by firm *N* in this situation makes firm *S* better off under Southern patent protection compared to no Southern patent protection.

If $F_S \in [G, H)$, whether or not firm *N* prefers Southern patent protection depends on the degree of product differentiation. There are two opposing effects on the profit of Firm *N*. If there is patent protection in the South, firm *S* invents *y* and firm *N* faces competition in both the South and the North. In contrast, if there is no Southern patent protection, firm *S*

only imitates the technology of firm *N* and firm *N* faces competition only in the South. If the products are close substitutes, thus creating intense competition between the firms, firm *N*'s gain in the Northern market under no Southern patent protection (compared to Southern patent protection) is greater than the loss in the Southern market and firm *N* is better off under no Southern patent protection. The opposite happens if the products are sufficiently differentiated.

Lastly, consider the case of high cost of Southern innovation (i.e., $F_S \in [H, \overline{F}_S)$). In this situation, firm S only imitates if there is no patent protection in the South but it innovates under Southern patent protection. The high cost of innovation reduces firm *S*'s net gain from innovation significantly and makes it better off under no patent protection in the South compared to Southern patent protection. For these costs of Southern innovation, firm *N*'s preference for Southern patent protection depends on the degree of product differentiation and the intuition is similar to the case of moderate costs of Southern innovation discussed above.

4. Welfare implications of Southern patent protection

Now, look at the welfare implications of Southern patent protection. Welfare of a country is the sum of consumer surplus and producer surplus of that country's firm. Producer Surplus of a country's firm consists of the profit from own country and the profit from the other country. Hence, welfare becomes "the consumer's utility plus the profit earned by own country's firm from abroad minus 'c multiplied by the total quantity of domestic consumption' minus profit earned by the other country's firm". We will also see the implications for world welfare, which is total welfare of the North and the South.

4.1. Patent protection in the South

Under patent protection in the South, firm *S* invents the new product by incurring the R&D cost F_S as long as $F_S < \bar{F}_S$, and the firms compete like Cournot duopolists in both the markets. The outputs of *x* and *y* sold in any country are given by $\frac{(a-c)}{(2+\gamma)}$.

Welfare of the North and the South are respectively

$$W_N^P = \frac{(a-c)^2(3+\gamma)}{(2+\gamma)^2} \quad \text{and} \quad W_S^P = \frac{(a-c)^2(3+\gamma)}{(2+\gamma)^2} - F_S. \tag{7}$$

The world welfare is

$$W_W^P = W_N^P + W_S^P = \frac{(a-c)^2(3+\gamma)}{(2+\gamma)^2} + \frac{(a-c)^2(3+\gamma)}{(2+\gamma)^2} - F_S. \tag{8}$$

4.2. No patent protection in the South

If there is no patent protection in the South, firm *S* innovates *y* and also imitates *x* when $F_S < G$. Hence, in the Northern market, firm *N* sells *x* and firm S sells *y*. However, both firms sell both the goods in the South. Therefore, welfare of the North is equal to '$u(x,y)$ + firm *N*'s profit earned in the South – $c(x_N + y_S)$ – firm *S*'s profit earned in the North'. Welfare of the South is equal to '$u(x,y)$ + firm *S*'s profit earned in the North – $c(x_N + x_S + y_N + y_S)$ – firm *N*'s profit earned in the South'.

Welfare of the North and the South are respectively

$$W_N^{NP} = \frac{(a-c)^2}{(2+\gamma)} + \frac{2(a-c)^2}{9(1+\gamma)} \quad \text{and} \quad W_S^{NP} = \frac{(a-c)^2}{(2+\gamma)^2} + \frac{2(a-c)^2}{3(1+\gamma)} - F_S. \tag{9}$$

World welfare in this situation is

$$W_W^{NP} = W_N^{NP} + W_S^{NP} = \frac{(a-c)^2}{(2+\gamma)} + \frac{2(a-c)^2}{9(1+\gamma)} + \frac{(a-c)^2}{(2+\gamma)^2} + \frac{2(a-c)^2}{3(1+\gamma)} - F_S. \tag{10}$$

If $F_S \geq G$, firm S does not innovate y but it imitates x. In that case, firm N is a monopolist in the North and the market in the South is duopoly where both firms N and S sell x. So, welfare in the North is equal to '$u(x)$ + firm N's profit earned in the South – $c(x_N)$' and welfare in the South is equal to '$u(x)$ – $c(x_N + x_S)$ – firm N's profit earned in the South'.

Welfare of the North and the South are respectively

$$W_N^{NP} = \frac{35(a-c)^2}{72} \quad \text{and} \quad W_S^{NP} = \frac{(a-c)^2}{3}. \tag{11}$$

World welfare in this situation is

$$W_W^{NP} = W_N^{NP} + W_S^{NP} = \frac{35(a-c)^2}{72} + \frac{(a-c)^2}{3}. \tag{12}$$

By comparing welfare of the North and the South, we get

Proposition 2: *(i) Assume that* $F_S < G$.

(a) Welfare of the North is higher under patent protection than under no patent protection in the South.

(b) Welfare of the South is higher under no patent protection than under patent protection in the South.

(ii) Assume $F_S \geq G$.

(a) Welfare of the North is higher under no patent protection (patent protection) than under patent protection (no patent protection) in the South if the degree of product differentiation is sufficiently (not sufficiently) small, i.e., $\gamma > (<)\gamma^*(= .79,$ *approx.).*

(b) Welfare of the South is higher (lower) under no patent protection than under patent protection in the South for $F_S > D$ *(*$F_S \in [G, D]$*).*

Proof: See Appendix B.

Figure 2 summarizes the above proposition.

[Figure 2 about here]

Proposition 2(i) supports the argument as to why the North favors patent protection in the South whereas South prefers no patent protection. However, Proposition 2(ii) shows that both the North and the South may prefer no patent protection in the South. Therefore, it is immediate that there are situations where imposition of patent protection in the South may actually reduce welfare in both countries.

Now discuss the intuition behind the above Proposition. For very low cost of innovation (i.e., $F_S < G$), both firms innovate irrespective of the Southern patent regime. If there is no patent protection in the South, both firms imitate each other's product and sell them in the South. Thus, the Southern market becomes very competitive and creates sufficiently large consumer surplus, which leads to higher welfare in the South under no patent protection compared to patent protection in the South. For these costs of innovation, North prefers Southern patent protection precisely because no patent protection in the South reduces the profit of the Northern firm in the South due to higher competition there.

For intermediate costs of innovation (i.e., $F_S \in [G, D]$), firm S does not innovate under no patent protection in the South, but it innovates under Southern patent protection. Hence, the South gains by imposing patent protection since it encourages firm to innovate and to enter the Northern market. However, firm *S*'s net gain from innovation is very low if the cost of innovation is above *D*, which, in turn, makes the Southern country better off under no patent protection in the South compared to Southern patent protection.

Northern welfare depends on the degree of product differentiation for $F_S \geq G$. If the products are close substitutes, it creates intense competition between the firms under Southern patent protection. In this situation, the reduction in profits of the Northern firm in both the Northern and the Southern markets are higher than the gain in consumer surplus in

the North due to higher competition,[10] which makes the Northern country better off under no Southern patent protection compared to patent protection in the South. However, if the goods are sufficiently differentiated, which soften competition between the firms, patent protection in the South does not reduce the Northern firm's profit significantly in either markets but it increases consumer surplus more significantly in the North. As a result, North is better off under patent protection in the South compared to no patent protection in the South.

Let us now discuss some interesting implications of our results. First, it is clear from the above analysis that there may be different types of conflicting interests between the countries as a whole and the firms. For small costs of innovation (i.e., $F_S < G$), the Northern firm, the Northern country and the Southern firm prefer patent protection in the South, whereas the Southern country prefers the opposite. So, there is a conflict of interests between the Southern firm and the Southern country regarding the choice of Southern patent regime. On the other hand, for intermediate costs of innovation (i.e., $F_S \in [G, H)$), it is possible that both the countries and the Southern firm prefer patent protection in the South, but the Northern firm prefers the opposite (this happens when $\gamma^c < \gamma < \gamma^*$). So, now the conflict is between the Northern firm and the Northern country. It may also happen that there is no conflict of interests between a country and its firm, though they may be in conflict across the countries and the firms. For instance, if $F_S \in [G, H)$ and $\gamma > \gamma^*$, the Southern firm and the Southern country prefer patent protection in the South but the Northern firm and the Northern country are better off under no patent protection in the South.

Second, our analysis suggests that all the parties may be better off under no patent protection in the South than under patent protection in the South. For high costs of innovation (i.e., $F_S > D$), both the Southern and the Northern countries prefer no patent protection in the South and the firms from the respective countries also prefer no patent protection in the South

[10] Note that, for these costs of innovation, firm *S* does not innovate if there is no patent protection in the South.

(this happens for $\gamma > \gamma^*$). As a result, all the parties are better off under no patent protection in the South.

The above implications suggest that the basic tenet of patent protection across the countries may be questionable even if under certain circumstances no Southern patent protection reduces the Northern firm's profit in the South. There should be a caveat at this point. The basic parametric configuration in our analysis ensures that the Northern firm always innovates. Hence, in our analysis, Southern patent protection does not affect the Northern firm's decision to innovate. However, if it so happens that no patent protection in the South reduces the Northern firm's profits so much that it discourages innovation by the Northern firm, the argument for Southern patent protection will be strengthened.

4.3. Implications for world welfare

The above analysis shows that there may be conflicting interests between the North and the South regarding the imposition of patent protection in the South. Hence, if the imposition of Southern patent protection is an outcome of a negotiation between the countries, Southern patent protection must increase world welfare for making the negotiation successful. Because, only if world welfare increases following Southern patent protection, a suitable compensation scheme can be designed to make each party better off under Southern patent protection compared to no Southern patent protection. The following proposition shows the implications of Southern patent protection on world welfare.

Proposition 3: *(i) If $F_S < G$, world welfare is higher under no patent protection than under patent protection in the South.*

(ii) Consider $F_S \geq G$. *World welfare is higher under patent protection than under no patent protection in the South if* $\gamma < \bar{\gamma}(=.83, approx.)$ *and* $F_S < M$, *where* $M = \frac{2(a-c)^2(3+\gamma)}{(2+\gamma)^2} - \frac{59(a-c)^2}{72}$.

Proof: See Appendix C.

If $F_S < G$, the Southern firm innovates irrespective of the Southern patent system. In this situation, imitation under no Southern patent protection increases Southern welfare by increasing competition in the South. However, higher competition in the South due to imitation under no Southern patent protection reduces Northern welfare by reducing the Northern firm's profit in the South, while the patent system does not affect competition in the Northern market. Therefore, a successful negotiation for Southern patent protection requires that the North must be able to compensate the South for its welfare loss. It follows from Propositions 2(i) and 3(i) that, if $F_S < G$, the Southern country's gain from no patent protection in the South is greater than the Northern country's loss from no Southern patent protection. Hence, if the cost of Southern innovation is very small, the negotiation between the North and the South for Southern patent protection cannot be successful since the North cannot compensate the South for its welfare loss following patent protection in the South.

If $F_S \geq G$, there can be a successful negotiation between the North and the South for Southern patent protection, since in this situation, Southern firm innovates only under Southern patent protection. The benefit from Southern innovation may increase world welfare following Southern patent protection (compared to no Southern patent protection) even if it reduces competition in the South through imitation. However, as expected, it depends on the degree of product differentiation, which affects the intensity of competition in the product

market, and the cost of Southern innovation, which affects Southern welfare and therefore, world welfare.

Proposition 2(i) shows that if $\gamma < \gamma^*$ and $F_S > D$, Southern patent protection increases Northern welfare while it reduces Southern welfare, thus again creating the need for compensating the South following Southern patent protection. If $\gamma < \gamma^*$, we get that $D < M$. Hence, it is immediate from Propositions 2(ii) and 3(ii) that, if $\gamma < \gamma^*$ and $F_S \in (D, M)$, Southern patent protection increases both world welfare and Northern welfare, while it reduces Southern welfare. Therefore, in situations where Southern patent protection induces innovation in the South, a compensation scheme may be designed to compensate the South for its welfare loss following the imposition of Southern patent protection.

Again, it should be remembered that to show the implications of Southern patent protection on Southern innovation, we have assumed that Southern patent system does not affect the incentive for Northern innovation. It is intuitive that if no Southern patent protection reduces Northern innovation, the benefit from Southern patent protection increases further and increases the possibility of a successful negotiation for imposing patent protection in the South.

5. The implications of costly and imperfect imitation

The above analysis was carried out with the assumption that, under no patent protection in the South, a firm could perfectly imitate the product of its competitor without incurring any cost. Now we discuss the significance of costly and imperfect imitation under no Southern patent protection.

Let us first consider the case where imitation under no Southern patent protection is perfect but involves a positive imitation cost, I, for both the Northern and the Southern

firms. It is immediate that the fixed cost of imitation, I , would reduce the net benefit from imitation by the same amount. Hence, in figure 1, though the cutoff value *G*, which comes from the comparison between OI and IR (see (6)), is not affected by the imitation cost, since the imitation costs under OI and IR cancel out. However, the imitation cost increases *H*. Since H comes from the comparison of the Southern firm's profit under patent protection and under no patent protection with the strategy OI (see (A.2) in the appendix), the positive imitation cost reduces the net benefit from no patent protection, thus increasing H . However, the Northern firm's preference remains unaffected over the parameter of product substitution. This is because the Southern firm does not innovate under no patent protection if the cost of innovation is $F_S > G$, and there is no possibility of imitation under patent protection. Hence, the Northern firm's preference remains the same under patent protection and under no patent protection in the presence of the positive imitation cost, and therefore, γ^c remains unchanged. Thus, in the presence of the positive imitation cost, the preference of the firms for different patent regimes can be found by replacing the cut off value H by *H+I.* Therefore, if the cost of imitation, *I*, is not too large so that $H + I < \overline{F}_S$, our qualitative results about the preference for different patent regimes remain. The positive cost of imitation compared to no cost of imitation only reduces the range of R&D costs over which no patent protection is preferable to patent protection.

Similar arguments will show that while comparing the welfare effects of patent and no patent protection with positive imitation costs, only the cut off value *D* in Figure 2 will be replaced by *D+I*. Hence, costly imitation reduces the incentive for no patent protection compared to patent protection from the welfare point of view.

It may also be possible that imitation does not allow the imitator to produce the imitated product at a marginal cost similar to that of the original product. Instead, the marginal cost of the imitated product becomes higher than the marginal cost of the original product, thus making imitation imperfect. Let us now consider that imitation is imperfect but

costless. Effectively this can be viewed as a type of cost under imitation, since imperfect imitation reduces the net benefit from imitation compared to perfect imitation. However, the main difference between costly imitation (i.e., the case of positive imitation cost) and imperfect imitation (i.e., the case of higher marginal cost of production of the imitated product compared to the original product) is that the latter situation affects the output decisions of the firms and therefore, the prices of the products, while the output decisions and the prices are unaffected under the former. As a result, imperfect imitation not only increases H but also increases G by reducing the benefit from imitation.[11] However, since the Northern firm's profit increases with imperfect imitation, it is immediate that γ^c is lower under imperfect imitation compared to perfect imitation. Hence, imperfect imitation (compared to perfect imitation) reduces the Southern firm's preference towards no patent protection, but it increases the Northern firm's preference towards no patent protection over a wide range of product substitutability. When it comes to welfare, the similar arguments will show that *D* will go up and γ^* will go down under imperfect imitation compared to perfect imitation.

6. Conclusion

The paper has dealt with a number of key issues related to the strengthening of patent protection in developing countries. In the context of North-South trading environment, we show that any 'blanket approach' for strengthening patent protection in the developing countries may not be justified in the presence of Southern innovation.

[11] While imperfect imitation reduces the Southern firm's profit under OI, thus increasing H under imperfect imitation compared to perfect imitation, the argument for higher G under imperfect imitation is as follows. The gross profits of the Southern firm under OI and IR are the same at $F_S = G$. Under IR, imperfect imitation (compared to perfect imitation) reduces the Southern firm's profit from *x* but increases its profit from *y*. However, the net effect of imperfect imitation is to increase the Southern firm's profit under IR, since the southern firm's gain due to the Northern firm's reduced capability of imitation dominates the Southern firm's loss due to its own reduced capability of imitation. On the other hand, the Southern firm's profit under OI reduces with imperfect imitation. As a result, imperfect imitation increases *G*.

Our analysis reveals some striking facts, which was hitherto not recognized in the literature. For example, it is not true that strengthening patent protection in the South would always increase the profit of the Northern firm or the Northern welfare. In fact, we show the situations where both the Northern firm and the Northern country would be better off under no patent protection in the South. We show that the skepticism of the Southern countries for strengthening their patent protection may be weak. In this respect, we identify a new factor, viz., the Southern firms' incentive to innovate and the opportunity to penetrate the Northern markets under Southern patent protection, which may indeed help to increase Southern welfare under Southern patent protection compared to no Southern patent protection. We also show that there might be conflict of interests between the countries and the firms. There may be the situations where all the parties are better off under no patent protection in the South. So, the implications of strengthening patent protection in the South depend on the cost of innovation and the degree of product differentiation. The paper also sheds light on the possible outcomes of international negotiation for implementing patent protection in the South. We show situations where Northern country may or may not be able to compensate the South for its welfare loss following the imposition of Southern patent protection.

Though our analysis questions the 'blanket approach' for strengthening patent protection in the South based on reasons different from the existing literature, and shows several interesting implications regarding profits and welfare, it is worth acknowledging that we have abstracted our analysis from several issues that need to be dealt with in the future. 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 each country, given the other specifications of the model, the market will be more competitive in every country. Now consider very low cost of innovation in the South. Then all firms in both the North and the South would innovate and they would serve both the markets. In this situation, the Southern firms would prefer patent protection in the South in

order to avoid imitation by all other firms. The Northern firms might prefer no patent protection in the South for closed substitutes, since that would eliminate further competition in the Northern market. However, if competition in the Northern market was already very intense, Southern patent protection would not increase competition in the North significantly, yet it would help the Northern firms to gain in the Southern market. In this situation, the Northern firms would prefer patent protection in the South. Hence, initial competition is important for affecting the Northern firms' incentives for Southern patent protection in the presence of Southern innovation.

As the cost of innovation goes up, the analysis will be complicated. For example, even if the Southern firms are symmetric in all respects, in equilibrium, some of them may not find it profitable to invent new products, when the others are inventing new products. As a result, the industry may consist of asymmetric firms (i.e., some with more products than others). However, it should be clear that, under patent protection in the South, the basic trade-off between lower imitation and higher innovation remains, and our qualitative results remain.

We have considered the degree of product differentiation as a parameter, which depends on the tastes and the preferences of the consumers and is not affected by the patent regime. However, by imposing novelty requirements in the patent law, the patent system may influence the degree of product differentiation that affects the market outcomes and welfare. Further, products with different degrees of differentiation may also need different amount of investment in innovation, thus may further complicate the matter. Since our analysis shows that the interests of the firms and the countries vary with respect to the degree of product differentiation, the conflict of interests is likely to remain even if the patent system influences product differentiation. A useful extension of our analysis will be to address the issue of patent breadth. The introduction of patent breadth, which can affect the degree of product differentiation, may have important implication for the oligopolistic markets, since it may

determine the number of firms that may exist in a particular market. The requirement for higher degree of product differentiation may increase the cost of innovation and reduce the number of innovations.

Finally, it may be worth considering the implications of patent protection in a dynamic setup by making the choice of patent length and patent breadth explicit and by incorporating other possible strategies of the firms, such as trade secrecy, for protecting their products. We intend to take up some of these issues in our future research.

Appendix

A Proof of Proposition 1: Let us first consider $F_S < G$. Here, firm *S* does IR under no patent protection in the South. It follows from (3) and (4) that both firms prefer patent protection in the South since $\frac{1}{(2+\gamma)^2} > \frac{2}{9(1+\gamma)}$ always holds for $\gamma < 1$.

Next, consider the situation where $\overline{F}_S > F_S > G$. In this situation, firm *S* does OI and the profits of the firms are given by (3) and (5). The profit of firm *N* is higher (lower) under patent protection than under no patent protection in the South if $\pi_N^P \gtreqless \pi_N^{OI}$, or

$$\frac{2}{(2+\gamma)^2} - \frac{1}{9} - \frac{1}{4} \gtreqless 0. \tag{A.1}$$

Left hand side (LHS) of (A.1) is positive at $\gamma = 0$. But LHS of (A.1) is negative at $\gamma = 1$. Since LHS of (A.1) is continuous and decreasing in γ, firm *N* is better off under patent protection than under no patent protection if γ is less than a critical value, $\gamma^c = .35$ (approx.). But, for $\gamma > \gamma^c$, firm *N* is better off under no patent protection in the South.

If $\overline{F}_S > F_S \geq G$, firm *S* is better off under patent protection (no patent protection) than under no patent protection (patent protection) in the South if $\pi_S^P \gtreqless \pi_S^{OI}$, or

$$\frac{2(a-c)^2}{(2+\gamma)^2} - \frac{(a-c)^2}{9} \gtreqless F_S. \tag{A.2}$$

It is easy to check that LHS of (A.2) is greater than G and less than $\frac{2(a-c)^2}{(2+\gamma)^2}$, where $\pi_S^P = 0$ at $F_S = \frac{2(a-c)^2}{(2+\gamma)^2} \equiv \overline{F}_S$ (see (3)). Defining the LHS of (A.2) by H, we get that firm *S* prefers patent protection (no patent protection) in the South for $F \in [G, H)$ ($F \in [H, \overline{F}_S)$). Q.E.D.

B Proof of Proposition 2: Let us first consider $F_S < G$. After rearranging, we find that, in this situation, welfare of the North is higher under no patent protection than under patent protection in the South if

$$\frac{2}{9} > \frac{(1+\gamma)}{(2+\gamma)^2}. \tag{B.1}$$

Right hand side (RHS) of (B.1) is negatively sloped with respect to γ over $\gamma \in [0,1]$ and is equal to LHS of (B.1) at $\gamma = 1$. Hence, it implies that condition (B.1) does not hold for any $\gamma \in [0,1)$. Therefore, welfare of the North is higher under patent protection than under no patent protection.

Now, compare welfare of the South under no patent protection and under patent protection in the South. Welfare of the South is higher under no patent protection than under patent protection if

$$\frac{2}{3(1+\gamma)} + \frac{1}{(2+\gamma)^2} > \frac{(3+\gamma)}{(2+\gamma)^2}. \tag{B.2}$$

It is easy to check that condition (B.2) holds for any γ less than 1. Hence, if $F_S < G$, welfare of the South is higher under no patent protection than under patent protection in the South.

Next, consider the case of $F_S \geq G$. Here, welfare of the North is higher under no patent protection than under patent protection if

$$\frac{35(a-c)^2}{72} > \frac{(a-c)^2(3+\gamma)}{(2+\gamma)^2}. \tag{B.3}$$

Condition (B.3) holds at $\gamma = 1$ but it does not hold at $\gamma = 0$. Since RHS of (B.3) is continuous and negatively sloped with respect to γ over $\gamma \in [0,1]$, (B.3) holds provided γ is greater than a critical value, $\gamma^* = .79$ (approx.), (which is greater than $\gamma^c = .35$). But, for $\gamma < \gamma^*$, welfare of the North is higher under patent protection than under no patent protection.

Now, consider the case of $F_S \geq G$. Welfare of the South is higher under no patent protection than under patent protection if

$$F_S > (a-c)^2 \left[\frac{(3+\gamma)}{(2+\gamma)^2} - \frac{1}{3} \right] = D. \tag{B.4}$$

It is easy to check that D is negatively sloped with respect to γ for $\gamma \in [0,1)$ and D is greater than G for all $\gamma \in [0,1)$.[12] So, welfare of the South is higher under no patent protection (patent protection) for $F_S > D$ ($F_S \in [G, D]$). Q.E.D.

C Proof of Proposition 3: (i) Consider $F_S < G$. In this situation, world welfare under no patent protection and under patent protection in the South are given by (8) and (10). Straightforward comparison of (8) and (10) shows that world welfare is higher under no patent protection in the South than under patent protection in the South.

(ii) Now consider the case of $F_S \geq G$. In this situation, world welfare under no patent protection and under patent protection in the South are given by (8) and (12), respectively. Comparison of (8) and (12) shows that world welfare is higher under patent protection in the South than under no patent protection in the South if

$$F_S < \frac{2(a-c)^2(3+\gamma)}{(2+\gamma)^2} - \frac{59(a-c)^2}{72} \equiv M \qquad \text{(C.1)}$$

Condition (C.1) can hold only if $M > G$. We get that $M > G$ if

$$\frac{(5+2\gamma)}{(2+\gamma)^2} - \frac{(1-\gamma)}{9(1+\gamma)} > \frac{59}{72}. \qquad \text{(C.2)}$$

Condition (C.2) is satisfied for $\gamma < \bar{\gamma}(=.83, approx.)$. Hence, if $\gamma < \bar{\gamma}$ and $G \leq F_S < M$, world welfare is higher under patent protection in the South than under no patent protection in the South. Q.E.D.

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[12] One can easily check that D is greater than H, which is defined in Appendix A.

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Firm N	Patent	| No patent (if $\gamma > \gamma^c$)	| No patent (if $\gamma > \gamma^c$)
		| Patent otherwise	| Patent otherwise
		G	H
Firm S	Patent	| Patent	| No patent

F_S →

Figure 1: Northern and Southern firms' preferences for patent and no patent in the South

North	Patent | No patent (if $\gamma > \gamma^*$)		No patent (if $\gamma > \gamma^*$)
	| Patent otherwise		| Patent otherwise
	G		D
	|		|
South	No patent | Patent		No patent

F_S →

Figure 2: Higher welfare of the North and the South under patent and no patent in the South