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Product vs. process patent

by

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Product vs. process patent

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Abstract: This paper provides a theoretical analysis of product and process patent regimes in the context of North-South trade. For some parametric configurations, we show that Northern government would favor the product patent regime in the South, although the Northern firm would prefer the process patent regime in the South leading to a conflict of interests between the Northern government and Northern firm. It is also possible that the Southern firm may prefer the product patent regime in the South whereas the Southern government prefers the opposite. Most interestingly, we find situations when Northern and Southern governments and both Northern and Southern firms are better off under the process patent regime in the South.

Key Words: Process patent, Product patent, North-South trade, Welfare

JEL Classifications: D45, L12, O33

Outline

Non-Technical Summary

The issue of similar patent standards across the countries led to a sharp division between the advanced developed countries (North) and the developing countries (South). In the Southern countries (e.g., India), the governments usually practice process patent regime and that too with varying degrees of enforcements under their laws. The North, on the other hand, always insisted on the product patent regime in the South as practiced in the North. The issue created lots of discussions since many Southern countries has to comply with the product patent in near future under the current WTO regime. In this context we provide an analysis on the issue of product versus process patent in the South and its welfare implications. More specifically, in an intra-industry trade framework, we ask whether there is any merit of continuing with the process patent regime in the South.

We provide a theoretical analysis of product and process patent regimes in the context of North-South trade. We show the situations where the Northern government would favor the product patent regime in the South, although the Northern firm would prefer the process patent regime in the South leading to a conflict of interests between the Northern government and Northern firm. It is also possible that the Southern firm may prefer the product patent regime in the South whereas the Southern government prefers the opposite. Most interestingly, we find situations when Northern and Southern governments and both Northern and Southern firms are better off under the process patent regime in the South.

1. Introduction

Under the current WTO (World Trade Organisation) regime, one of the most debated issues in international negotiation is the issue of standardizing (and strengthening) the patent systems across the world. The debate gathered momentum due to the Dunkel proposal related to Trade Related Intellectual Property Rights (TRIPS). The issue of similar patent standards across the countries led to a sharp division between the advanced developed countries (North) and the developing countries (South). In the Southern countries (e.g., India), the governments usually practice process patent regime and that too with varying degrees of enforcements under their laws.[1] The North, on the other hand, always insisted on the product patent regime in the South as practiced in the North. The issue created lots of discussions since many Southern countries has to comply with the product patent in near future under the current WTO regime. In this context we provide an analysis on the issue of product versus process patent in the South and its welfare implications. More specifically, in an intra-industry trade framework, we ask whether there is any merit of continuing with the process patent regime in the South.

The question of whether the North prefers product or process patent in the South is very important. The conventional economic reason underlying the conflict of interest between Northern and Southern countries is easy to see. Northern countries are the major producers of newer technologies. Southern countries are almost totally dependent on the North for technologies needed for their growth and development. In case of process patent in the South, it is often be the case that the Southern firm develops a different process of production that uses some of the cheap resources available in the South. As a result the Northern firm faces competition from the Southern firm in the Southern market and thereby it is deprived of some of the monopoly benefits it could derive from selling the product in the South. On the other hand, if South practices product patent, Northern firm is protected from any competition in the same product in the Southern market. Thus, product patent in the South would allow Northern firm to get the monopoly benefit in the

[1] This is in the context of the empirical findings on patent protection in developing countries. In International Finance Corporation's survey (Mansfield, 1994) of 16 countries it was reported that the countries perceived to have the weakest patent protections are India, Thailand, Brazil and Nigeria.

South. Hence, the Northern firm would prefer the product patent in the South and it is believed that the incentive of a firm to introduce new products would be higher.

The above view neglects some of the interesting dimensions of product versus process patent in the context of intra-industry trade. Consider a world characterized by product patent in the North and process patent in the South. Suppose, the Southern firm can innovate new products as well as do process innovation of the existing product of the Northern firm. In this situation, the Northern firm can also undertake process innovation of the Southern firm's new product and sell the product in the South (due to process patent there). However, due to product patent in the North, Southern firm can enter the Northern market only with a different product. Once we consider innovation by the Southern firm and imitation by the Northern firm, some of the conventional wisdom might go wrong.

It is worth noting that innovation by the Southern firm is not just a theoretical possibility but is very much relevant in today's world. Many Asian countries such as South Korea, India and Taiwan are inventing new products those are competing with the existing products of the developed countries' firms. For example, many developing and newly industrialized countries such as India, Singapore, Taiwan and a number of Latin American countries are showing significant participation in software and also in hardware industries (Correa, 1990). Recent paper by Tsai and Wang (2004) also provides evidence of significant research and development (R&D) effort in Taiwan's electronics industry. The emergence of newly industrialized Asian countries has encouraged recent research to consider the implications of R&D by the developing countries (e.g., Khemarat, 2004).

We show that if the cost of doing R&D in the Southern country is not very small, Northern firm is better off under the process patent regime in South when the products are not sufficiently differentiated. We also find that there are costs of Southern R&D and the degree of product differentiation such that Northern government favors product patent in South while Northern firm prefers process patent in South. This suggests that product

patent in South may make the Northern firm worse off but benefits the consumers in the Northern country. Hence, there might be a conflict of interests between Northern government and Northern firm. Interestingly, we also find that if the cost of doing R&D in South is sufficiently small, Southern firm is better off under product patent in South. Most interestingly, we find that when the costs of doing Southern R&D is sufficiently high and the goods are very close substitutes, the Northern and Southern governments and both Northern and Southern firms are all better off under the process patent regime in the South. So, in the context of intra-industry trade, the possibility of both product and process innovations by the Southern country along with imitation by the Northern firm adds new and valuable insights on the discussion of product versus process patent. Thus, we show that the 'blanket' approach of WTO towards standardizing the product patent regime in South is questionable.

The remainder of the paper is organized as follows. Section 2 reviews the previous literature relevant to this paper. Section 3 presents the basic model. Section 4 shows the market structure that evolves under the product and the process patent regimes practiced in the South. Section 5 focuses on welfare implications of different patent regimes. Section 6 concludes.

2. Literature review

The literature on patent protection in the North-South trading environment has mainly focused on the issue of strengthening the patent protection by the Southern government in terms of making the imitation of the Northern technology more difficult. The theoretical literature does not support the idea of universal patent protection for higher innovation rate and welfare.[2] In dynamic contexts, the issue of patent protection and its impact on innovation rate and welfare are discussed by many authors such as Grossman and Helpman (1991), Helpman (1993), Segerstrom *et al*. (1990) and Lai

[2] Among the recent literature without any North-South consideration Bessen and Maskin (2000) show that if innovation is sequential and complementary (as in certain industries like software, semiconductors and computers) stronger patent protection would limit imitation and thereby inhibit technological change.

(1998).[3] Their findings seem to contradict the intuition furnished by Schumpeter (1942) and subsequently by Romer (1991) that stronger patent protection should encourage innovation.

Chin and Grossman (1990) studied the welfare implications of patent protection in a North-South trading environment. In their model, global patent protection stimulates innovation in the North but whether global welfare goes up or down depends on the productivity of Northern R&D. Diwan and Rodrik (1991) argued that when North and South have different tastes, and technological and R&D resources are limited, Southern patent protection might have a role in promoting the development of technologies appropriate for South. They showed that increased patent protection in South might not be good for North, as more R&D resources would be deployed to suit Southern tastes. Deardorff (1992) also argued for limiting patent protection geographically rather than extending it universally across the world.

Glass and Saggi (2002) provide another resource-based argument against stronger patent protection. In a product cycle model with endogenous innovation, imitation and foreign direct investment, they argue that stronger intellectual property rights lead to more resources used for imitation, which in turn reduces FDI and consequently contracts innovation. In the context of strategic interactions between firms, Taylor (1994) discussed that failure of a country to provide patent protection to the foreign innovations forces the innovators to employ 'less than best practice technology' and reduces aggregate R&D and worldwide growth.[4]

[3] In the first three papers, imitation is the only channel of international production transfer from North to South. Lai (1998) introduced the issue of foreign direct investment (FDI) with the modifications that Southern firms can imitate only after Northern firms transfer production to South. He concludes that stronger patent protection in the South increases the rate of product innovation if FDI is the channel of production transfer and has an opposite effect if production is transferred through imitation.

[4] In the context of technology transfer where the different modes of technology transfer like licensing and wholly owned subsidiary are considered (Vishwasrao, 1994, Markusen, 2001, Fosfuri, 2000 and Sinha, 2001), the general conclusion is that strengthening of patent protection does not necessarily lead to an increase in innovation rate or welfare.

The above papers have addressed the question of stronger intellectual property right under the process patent regime in South. Recently, Marjit and Beladi (1998) address the question of process versus product patent in the South. They show that if there are significant dispersions in international income distribution, product patent may prevent Northern firm to serve Southern market, which may provide a rationale for continuing process patent in South. However, unlike the present paper, which allows innovation by Southern firm and also knowledge diffusion from South to North, all the above-mentioned papers consider technology diffusion from North to South only.

3. The basic model

Consider two countries, called North and South, with separated markets. Assume that there is one firm in each of North and South and call these firms as firm N and Firm S respectively. For simplicity, we assume that at the beginning of the game neither firm has any technology to produce a good. These 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, in our analysis, we will always assume the imposition of product patent regime in the North, we will consider the impact of product and process patent regimes in South. Since, North always imposes product patent, it implies that only the original innovator can sell its product in the North market but no one else can sell its product in the North by imitating this technology. Similar situation also holds in the South when South imposes the product patent regime. But, in case the South imposes the process patent regime, both firms are allowed to do non-infringing imitation of the competitor's technology and sell the same product in the South.

We consider the following three stage game. In stage 1, the firms take decision on R&D to invent technology for a new product. We assume that firm N is trying to invent the technology of a product x, while firm S is trying to invent the technology of a product y. We consider that the products x and y are imperfect substitutes.[5, 6] We assume that

[5] This structure of producing different products with different technology is similar to Eswaran (1994).

each firm can invent a single technology at one point of time, which implies a restriction on the R&D capacity.[7] Since, we consider the products x and y as imperfect substitutes, it is easy to understand each firm will prefer to invent a technology different from its competitor.[8] In stage 2, the firms take decision about imitating the technology of the other firm. In 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 innovative R&D and therefore, it requires lower investment to invent the new technology. 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 cost of the Southern firm for doing innovative R&D is $F_S = F_N + F$. Further, to economize on the notation, we normalize the cost of innovative R&D of firm N to 0.[9]

We assume that both firms are symmetric with respect to imitation. For simplicity, we further assume that imitation is costless. This assumption of costless imitation is consistent with the assumption of knowledge spillover in the previous works mentioned in the introduction.[10]

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[6] The assumption of imperfect substitutes can be consistent with product patent if we consider that the degree of substitutability depends on the tastes and preferences of the consumers. For example, even if manual type-writer is different from electronic type-writer or computer, these products may be imperfect substitutes depending on the tastes and preferences of the consumers.

[7] In real world, we don't find one firm is investing in all the products. This may be due to strategic reason or may be due to physical constraint on the capacity in R&D. We assume the latter and consider that each firm can invent a single technology at any point of time.

[8] This possibility of inventing a technology may lead to a coordination problem in the R&D stage, i.e., which firm will invent which technology. However, since our purpose is not to look at the problem of coordination, we are assuming away this possibility and considering that firm N invests to invent x and firm S invests to invent y. The flow of information at the R&D stage and slight early investment of one of these firms may solve this coordination problem.

[9] This assumption does not affect our qualitative results as long as firm N always does innovation in equilibrium, which we will consider throughout our analysis. This will be consistent with the previous papers where Northern firms' are more prone to innovation.

[10] The assumption of costless imitation will imply that imitation is profitable to both firms whenever patent protection allows this. Our qualitative results will hold even if imitation is costly but the cost of imitation is sufficiently low such that it is profitable to both firms whenever possible. However, sufficiently high cost of imitation may result in two pure strategy equilibria where it is optimal for a firm not to do imitation when its competitor imitates. Since, this possibility of multiple equilibria will not add new insights to our analysis but will only complicate the analysis, we are ignoring this possibility here.

We consider the following demand structure in each country for our analysis. We assume that the representative consumer's utility is a function of consumption x, y and the numeraire good m, and 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.[11] If $\gamma=0$, this implies that the products of these firms are isolated but for $\gamma=1$, the products are perfect substitutes. Since, we are considering the technology of y is different from the technology of x, we rule out the possibility of perfect substitutes and assume that $\gamma\in[0,1)$.

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

$$P_x = a - x_1 - x_2 - \gamma y_1 - \gamma y_2, \tag{1}$$

and

$$P_y = a - y_1 - y_2 - \gamma x_1 - \gamma x_2, \tag{2}$$

where P_x and P_y are the prices of x and y and a is positive. Further, for simplicity, we assume that constant average cost of production for x and y are given by c, which is same for both firms and $c<a$.

4. Implication on profits

4.1 Product Patent Regime

Let us first consider the situation under the product patent regime in South. Since, under product patent in South, neither firm can sell its product using the imitated technology, imitative R&D is not an option to these firms. In this situation, if firm S invents the new product by incurring the cost of R&D F_S, these firms compete like Cournot duopolists in both North and South markets. So, in this situation, the outputs of x and y in each country is $\frac{(a-c)}{(2+\gamma)}$. Profits of the firms are

[11] This utility function is typical in the literature (see, e.g., Singh and Vives, 1984).

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

4.2 Process patent Regime

Now consider the situation under process patent in South. After the decision on innovative R&D in stage 1, the firms decide on the imitative R&D in stage 2. Since, the cost of imitation is negligible, it is easy to check that, in stage 2, each firm finds it profitable to imitate the technology of the other firm, given that the other firm has invented the technology in stage 1.[12]

Let us now examine the decision of stage 1. Note that firm N always innovates x. However, it is not immediate whether the firm S also finds it optimal to innovate y. Knowing that, firm N innovates x and imitation is optimal in stage 2, firm S has two strategies in stage 1: (i) to innovate y and imitate x in stage 2 (IR) or, (ii) don't innovate y and imitate x in stage 2 (OI). Under IR, firm S will sell both products in the South and y in the North. But, in case of OI, firm S sells only x in the South and nothing in the North.

If firm S does innovation in stage 1, i.e., IR, then the firms compete in both North and South. In the North, firm N sells good x and firm S sells y. But, each firm sells both products in the South. So, the amount of x and y sold in the North is $\frac{(a-c)}{(2+\gamma)}$ and each firm supplies $\frac{(a-c)}{3(1+\gamma)}$ units of each good in the South. Profits of the firms are

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

If firm 2 does not innovate in stage 1, i.e., OI, then, given the product patent in the North, firm N becomes monopoly in the North. However, both firms sell the product x in

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

South. In this situation, the equilibrium output in the North is $\frac{(a-c)}{2}$, and, in the South, each firm sells $\frac{(a-c)}{3}$ units of good x. Therefore, profits of the firms are

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

However, firm S does OI instead of IR provided

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

Hence, if $F_S < G$, profits of the firms under the process patent regime are given by (4). On the other hand, if $F_S > G$, profits of the firms under the process patent regime are given by (5).

4.3 Comparing the profits under product and process patent regimes

Let us consider the situation $F_S < G$. Here firm S does IR under process patent in South. It follows from (3) and (4) that, in this situation, both firms always prefer product patent in South since here $\frac{1}{(2+\gamma)^2} > \frac{1}{9(1+\gamma)}$.

Next, consider the situation where $F_S > G$. In this situation, firm S does OI and the profits of the firms are given by (3) and (5).

Profit of firm N is higher (lower) under product patent compared to process patent in the South provided $\pi_N^{PDP} \gtreqless \pi_N^{OI}$, or

$$\frac{2}{(2+\gamma)^2} - \frac{1}{9} - \frac{1}{4} \gtreqless 0. \tag{7}$$

Left hand side (LHS) of (7) is positive at $\gamma = 0$. But LHS of (7) is negative at $\gamma = 1$. Since, LHS of (7) is continuous and decreasing in γ, firm N is better off under product patent compared to process patent provided γ is less than a critical value, say γ^c. But,

for $\gamma > \gamma^c$, firm N is better off under process patent in South. It can be found that $\gamma^c = .35$ (approx.).

If $F_S > G$, firm S is better off under product (process) patent compared to process (product) patent in South provided $\pi_S^{PDP} \gtreqless \pi_S^{OI}$, or

$$\frac{2(a-c)^2}{(2+\gamma)^2} - \frac{(a-c)^2}{9} \gtreqless F_S. \tag{8}$$

It is easy to check that LHS of (8) is greater than G and less than $\frac{2(a-c)^2}{(2+\gamma)^2}$, where $\pi_S^{PDP} = 0$ at $F_S = \frac{2(a-c)^2}{(2+\gamma)^2}$ (see (3)). Defining the LHS of (8) by H, we get that firm S prefers product (process) patent in South for $F \in (G, H)$ ($F \in (H, \pi_S^{PDP} = 0)$).[13]

The following proposition summarizes the above discussions.

Proposition 1: *(i) If the costs of innovation are sufficiently small, i.e., $F_S < G$, both firms always prefer product patent in South.*

(ii) If the costs of innovation are intermediate, i.e., $F_S \in (G, H)$, firm S always prefers product patent in South. For these costs of innovation, firm N prefers process (product) patent in South for $\gamma > (<)\gamma^c (= .35$, approx.).

(iii) If the costs of innovation are sufficiently large, i.e., $F_S \in (H, \pi_S^{PDP} = 0)$, firm S always prefers process patent in South. For these costs of doing R&D, firm N prefers process (product) patent in South for $\gamma > (<)\gamma^c$.

Figure 1 provides a graphical representation of the above proposition.

Figure 1

The intuition behind this proposition is as follows. First, note that the underlying market structure for different costs of innovation is the crucial factor behind the above

[13] We assume that firm S does product innovation provided it earns net positive profit. So, the values of F_S are such that $\pi_S^{PDP} > 0$.

preference pattern of the firms. In case of product patent in the South, imitation is not an option and both firms invent for $F_S < \pi_S^{PDP} = 0$. But, in case of process patent regime in the South, imitation is a feasible option and therefore, innovation by firm S may not be the optimal strategy. For very low cost of product innovation ($F_S < G$) both firms innovate new technologies and also imitate the technology of the other firm under process patent in the South. This threat of imitation faced by both firms reduces their benefits from innovation significantly and therefore, both firms are better off under product patent in the South.

If the cost of doing R&D is intermediate ($F_S \in (G, H)$) firm S does not innovate y but imitates x under process patent. Therefore, for these costs of innovation, process patent in the South reduces the firm S's incentive for inventing a new product since imitation provides an option for receiving positive profits and hence, increases the reservation payoff of firm S. Since, imitation is not an option under product patent in the South, firm S should invent the new product if it wants to receive positive profit. Further, if firm S invents the new product, it can sell it to the Northern market as well. Process patent in the South eliminates this incentive of firm S. So, firm S is better off under product patent in the South.

However, for $F_S \in (G, H)$, whether firm N prefers process patent or product patent depends on the degree of substitutability. There are two opposing effects on the profit of Firm N. If there is product patent in the South, firm S invents product y and competes with firm N in the Northern market. As a result, firm N looses its monopoly position in the Northern market. In contrast, in case of process patent in the South, firm S imitates the technology of firm N only and competes in the South only. Hence, in case of process patent regime in the South, firm N gains in the Northern market but it looses in the Southern market, compared to the product patent regime. If the products are close substitutes, the gain in the Northern market is greater than the loss in the Southern market and firm N is better off under process patent. But, for sufficiently differentiated products,

firm N's loss in the Southern market is greater than its gain in the Northern market and hence, firm N prefers product patent in the South.

For sufficiently high cost of innovation ($F_S \in (H, \pi_S^{PDP} = 0)$), firm S does imitation only under process patent but does innovation under product patent. Since here the cost of innovation is sufficiently high, the gain from inventing the new product and entering the Northern market is significantly low and makes the firm S better off under process patent, where it imitates the product of firm N and competes in the Southern market only. However, for these costs of innovation also, firm N's preference depends on the degree of product substitutability and the logic is similar to the case of intermediate costs of innovation mentioned above.

5. Welfare implications

So far, we have examined the preferences of the firms. Now, we will examine the implications of different patent regimes on welfare of North and South.

Note that the welfare calculations can be made independently for each country depending on the amount of goods supplied and the profits of the firm located in the country.[14] We define welfare as the summation 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. Thus, welfare becomes "the consumers' 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 other country's firm".

5.1 Product patent regime in South

Let us first consider the situation under product patent in the South. In this situation, firm S invents the new product by incurring R&D cost F_S and the firms compete like Cournot

[14] The firms are considering the markets in a segmented fashion and competing in a given market. Since the firms can produce goods at constant marginal cost, the supply to any given country does not affect the marginal profitability in the other country.

duopolists in both North and South markets. Hence, in this situation, the outputs of x and y sold in any country is given by $\frac{(a-c)}{(2+\gamma)}$.

So, welfare of the North and the South are respectively

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

5.2 Process patent regime in South

In case of process patent in the South, firm S innovates y and also imitates x when $F_S < G$. So, the Northern market would be supplied with x by firm N and y by firm S but both firms will supply both the goods in South.

So, welfare in 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 in 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'.

Hence, welfare of the North and the South are respectively

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

If $F_S > G$, firm S does not innovate y but it imitates x. In that case, firm N is monopoly in the North and the market in the South is duopoly where both firms N and S supply the good x.

So, welfare in the North is equal to '$u(x)$ + firm N's profit earned in 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 South'.

Hence, welfare of the North and the South are respectively

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

5.3 Comparing welfare under the product and the process patent regimes

Let us first consider the situation where $F_S < G$. After rearranging, we find that, in this situation, welfare of North is higher under process patent compared to product patent in South provided

$$\frac{2}{9} > \frac{(1+\gamma)}{(2+\gamma)^2}. \tag{12}$$

Right hand side (RHS) of (12) is negatively sloped with respect to γ over $\gamma \in [0,1]$ and is equal to LHS of (12) at $\gamma = 1$. Hence, it implies that condition (12) does not hold for any $\gamma \in [0,1)$ and therefore, welfare of North is always higher under product patent compared to process patent.

Now, compare welfare of South under process and product patents in South. Welfare of South is higher under process patent compared to product patent provided

$$\frac{2}{3(1+\gamma)} + \frac{1}{(2+\gamma)^2} > \frac{(3+\gamma)}{(2+\gamma)^2}. \tag{13}$$

It is easy to check that condition (13) holds for any γ less than 1. Hence, if $F_S < G$, welfare of South is always higher under process patent compared to product patent.

Next, consider the case of $F_S > G$. Here, welfare of North is higher under process patent compared to product patent provided

$$\frac{35(a-c)^2}{72} > \frac{(a-c)^2(3+\gamma)}{(2+\gamma)^2}. \tag{14}$$

Condition (14) holds at $\gamma = 1$ but does not hold at $\gamma = 0$. Since RHS of (14) is continuous and negatively sloped with respect to γ over $\gamma \in [0,1]$, condition (14) holds provided γ is greater than a critical value, say, γ^*. But, for $\gamma < \gamma^*$, welfare of North is higher under product patent compared to process patent. It can be found that $\gamma^* = .79$ (approx.) and it implies that $\gamma^* > \gamma^c$.

Now, consider welfare of South under process and product patents in South when $F_S > G$. Welfare of South is higher under process patent compared to product patent provided

$$F_S > (a-c)^2\left[\frac{(3+\gamma)}{(2+\gamma)^2} - \frac{1}{9}\right] = D. \qquad (15)$$

It is easy to check that RHS of (15) is positively sloped over $\gamma \in [0,1]$ and D is greater than G for all $\gamma \in [0,1)$.[15] So, welfare of South is higher under process (product) patent provided $F_S > D$ ($F_S \in (G,D)$).

The following proposition summarizes the above discussion.

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

(a) Welfare of North is always higher under product patent in South compared to process patent in South.

(b) Welfare of South is always higher under process patent in South compared to product patent in South.

(ii) Assume $F_S > G$.

(a) Welfare of North is higher under process (product) patent in South compared to product (process) patent in South provided the degree of product differentiation is sufficiently (not sufficiently) small, i.e., $\gamma > (<)\gamma^*(= .79,$ *approx.).*

(b) Welfare of South is higher (lower) under process patent in South compared to product patent in South provided $F_S > D$ *(*$F_S \in (G,D)$*).*

Figure 2 summarizes the above proposition.

Figure 2

Proposition 2(i) favors the North's argument for product patent in South, whereas South prefers process patent in South. But Proposition 2(ii) shows that both Northern and Southern governments might prefer process patent in South. Therefore, the governments' preferences for process patent are perfectly in sync. Thus, the 'blanket' imposition of product patent system under the WTO regime reduces welfare in both countries.

[15] One can easily check that D is greater than H, which is defined in the previous section.

Both firms always do product innovation for very low R&D cost (i.e., $F_S < G$), irrespective of the type of patent protection in South. So, under the process patent regime in South, both firms also imitate each other's product and sell them in South. Thus, the Southern market becomes very competitive and creates sufficiently large consumer surplus, which leads to higher welfare in South under the process patent regime compared to the product patent regime. But, for these R&D costs, North prefers the product patent regime in the South precisely because the profit earned by the Northern firm in South under process patent is low due to higher competition in South. If the R&D costs are intermediate (i.e., $F_S \in (G, D)$), firm S would not undertake product innovation under the process patent regime in South, but would innovate the new product under the product patent regime in South. Hence, South gains by implementing the product patent regime since it encourages firm S to do product innovation and to enter the Northern market. But, firm S's net profit under product innovation becomes low when the R&D cost is above D, which, in turn, makes the Southern country better off under the process patent regime than the product patent regime.

Northern welfare depends on the degree of product differentiation for $F_S > G$. If the products are very close substitutes, it creates tough competition between the firms under the product patent regime in South. In this situation, the reduction in profit of firm N in the Northern and Southern markets is higher than the gain in consumer surplus in North, which makes the Northern country better off under the process patent regime in South compared to the product patent regime in South.[16] But, if the goods are sufficiently differentiated, the product patent regime in the South does not reduce the profit of firm N significantly in the Northern and Southern markets but it increases consumer surplus in the North significantly. Therefore, in this situation, North is better off under the product patent regime in South than the process patent regime in South.

Let us now discuss the significance of our analysis. For small R&D costs (i.e., $F_S < G$) we find that the Northern firm, the Northern government and the Southern firm

[16] Note that, for these costs of R&D, firm S does not undertake product innovation under the process patent regime in the South.

prefer the product patent regime in South, whereas the Southern government prefers the opposite. So, there is a conflict of interests between the Southern firm and the Southern government regarding the choice of patent regime in South. On the other hand, for intermediate range of R&D costs (i.e., $F_S \in (G,H)$), it is quite possible that both the governments and the Southern firm prefer the product patent regime in 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 Northern government. It is also true that the Southern firm and the Southern government prefer the product patent regime but the Northern firm and the Northern government are better off under the process patent regime in the South (when $F_S \in (G,H)$ and $\gamma > \gamma^*$).

For large enough R&D costs (i.e., $F_S > D$), both the Southern and Northern governments prefer the process patent regime in South and firms from the respective countries also prefer the process patent regime in South (this happens when $\gamma > \gamma^*$) and as a result, all parties are better off under the process patent regime in South. Thus, our analysis questions the basic tenet of the standardizing the patent system across the world and also reflects that it is not clear whose interest is served through the blanket imposition of the product patent regime in South.

6. Conclusion

In the context of patent protection one important question is whether the Northern country always prefers the product patent regime as opposed to a process patent regime in South. Without any explicit theoretical analysis on the issue, the current discussion on intellectual property rights has implicitly taken it for granted that implementing the product patent regime in the South would be the best for the North. This paper provides a theoretical analysis of product and process patents in the context of North-South trade. More specifically, we ask whether Northern firm as well as the Northern country would necessarily benefit from introducing product patent as opposed to the process patent in South. This question has been asked in an imperfectly competitive product market with differentiated products.

The theoretical analysis reveals some striking facts, which was hitherto not recognized in the literature. For example, it is not true that introducing product patent in the South would always maximize the Northern firm's profit or Northern country's welfare. In fact we find some parametric configurations for which both Northern firm and Northern government would favor a system of process patent in South. This finding questions the basis of the 'blanket' approach of WTO towards a standardized patent system in favor of product patent in South. We find that there might be conflict of interest between the Northern government and Northern firm, and also Southern government and Southern firm. For some parametric configurations, we show that Northern government would favor the product patent regime in the South, although Northern firm would prefer the process patent regime in the South. This points towards the fact that introduction of product patent in South might serve the purpose of the Northern country but it hurts the Northern firm. It is also possible that the Southern firm may be better off under the product patent regime in South whereas the Southern government prefers the opposite. Most interestingly, we find situations when both governments and both firms are better off under the process patent regime in South. We also find some parametric configurations where the Southern firm and the Southern government may prefer the product patent regime in South but the Northern firm and the Northern government prefer the process patent regime in South Thus, the analysis brings into light some of the interesting issues related to process and product patent regimes in the South and provides new insights into this discussion.

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Firm N	Product patent	Process patent (if $\gamma > \gamma^c$)	Process patent (if $\gamma > \gamma^c$)
		Product patent otherwise	Product patent otherwise
		G	H
Firm S	Product patent	Product patent	Process patent

F →

Figure 1: Northern and Southern firms' preferences over process and product patent regimes

North	Product patent	Process patent (if $\gamma > \gamma^*$)	Process patent (if $\gamma > \gamma^*$)
		Product patent otherwise	Product patent otherwise
		G	D
South	Process patent	Product patent	Process patent

F →

Figure 2: Higher welfare to North and South under product or process patent regimes