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# WILL ALL SOUTHERN COUNTRIES EXTEND PATENT PROTECTION TO NORTHERN INNOVATIONS?

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*Abstract*: We consider a framework of one north and two southern countries where only the north can innovate but the southern countries can imitate; however, the innovation decision is endogenous—the size of the innovation depends on the extent of patent protection by the countries as a whole. We show that even if the southern countries are identical in all respect, their optimal policies might differ. In particular, we portray situations when, in a subgame perfect Nash equilibrium, one southern country accepts foreign patent protection and the other country rejects it. In our analysis we focus on the factors like imitative capability, product life vis-a-vis the patent length, and the nature of the innovation function.

**Key words:** Intellectual property, patent protection, innovation, imitation.
**JEL Classification Number:** F23, L14, O34.

## 1. INTRODUCTION

The Uruguay Round of GATT included intellectual property (IP) issues on its agenda. It is said that through the forum like the GATT, the developed countries, the north, wanted to enforce their patent laws to the rest of the world. The member countries had no much flexibility but to either accept or reject the whole package of proposals, known as trade related intellectual property rights (TRIPs). This created a lot of debate and

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dissension within and outside each country. While the member countries have signed the GATT treaty with utter discontent, the debate has not yet died down.

The source of the debate on the issue of intellectual property rights (IPRs) between the north and the south may be discussed as follows.[1] The developed countries think that intellectual property rights should be respected because inventive activity involves huge amount of expenditures and risks, but the inadequate and ineffective protection gives rise to production and trade in counterfeit goods, resulting in losses of sales and exports. In the absence of effective patent protection the private investors will not get sufficient incentives for doing innovating activity, and as a result interests of all countries will be adversely affected. The developing countries, on the other hand, are of the opinion that since most of the innovations occur in the north, TRIPs would give the developed countries absolute power to rule over the developing countries in future trade and technology matters.

Since then a number of celebrated papers have come out in the literature on this issue. This discusses and examines different aspects of the proposals on TRIPs. Surprisingly, almost the whole literature assumes a north-south global division and studies the problem as a north-south conflict. This literature includes Chin and Grossman (1991), Maskus (1990), Deardorff (1990, 1992), Diwan and Rodrik (1991), Helpman (1993), Taylor (1994), Aoki and Prusa (1993), Vishwasrao (1994), etcetera. A brief description of this literature is provided in Kabiraj (2000).

But one gap in the literature is evident. The existing literature clubs all developing countries into a single "south", but, as it is quite obvious, these countries differ among themselves very widely. If not, possibly they could exert pressure in a more coordinated and organized manner on the northern countries in the forum like the GATT. But the fact is that their interests not only differ but sometimes conflict on several aspects of the issue.

The conflict of interests within southern countries was mooted for the first time in Kabiraj (1995). However, the paper defined patent protection narrowly. Accordingly, patent protection prevents imitators from competing with the innovating firm in the domestic country, but it does not preclude imitators from exporting imitations to other countries which do not protect patents. Hence a broad based patent protection, consistent with the GATT rules, is considered in Kabiraj (2000). In any case, Kabiraj considers a framework with one innovating north and two imitate-capable southern countries, and then studies the question of incentives of each southern country to extend patent protection to northern innovations. The southern countries differ in respect of market sizes and technological capabilities. It is shown that under some conditions, the more-capable imitating country will accept northern patent protection. The idea is that the real threat to the northern innovators comes from these relatively more capable imitating countries, and then by giving no protection, a country faces a credible threat of being deprived of the benefits of new innovations.

[1] See Kabiraj (1994) for related other issues.

But Kabiraj (2000) assumes that innovations are exogenous in the sense that honor or dishonor by any southern country will have no effect on the size of the innovations. The assumption of exogenous innovation and more than one southern country would commonly mean that in equilibrium no country should accept patent protection. In contrary, the paper has shown that the existence of more than one southern country and their interaction will lead the more capable imitating country to accept international patent protection.

Yang (1998) has also studied the question of why the southern countries have little incentive to protect northern IPRs. Since each country can gain by free-riding on others, the overall protection becomes insufficient for the northern innovators. Since by these all countries lose, the paper suggests for some mutual cooperation among the southern countries and between the north and the south.

The present paper seeks to endogenize the northern innovation decision. We have the same framework as in Kabiraj (2000), but the assumption of "exogenous innovation" is dropped. Hence now the innovation size is determined endogenously, that is, innovation now depends on the extent of patent protection by all countries together. We assume that the north always gives patent protection to its innovators. Then the question is: Will all southern countries extend protection to northern innovations? While there are plenty of differences across developing countries that might explain their differences in policy on this front, but interestingly, as we show in the paper, the optimal policies could differ even if the countries do not. Therefore, the purpose of this paper is to portray circumstances in which the otherwise identical countries might, in a subgame perfect Nash equilibrium, some choose to provide protection and others not. While patenting decision of a country depends on a large number of factors, in this paper we focus, in particular, on the factors like the slope and curvature of the northern R&D production function, the length of patent protection vis-a-vis the life of the product, the market share of the southern countries in the world demand, and on the imitating or technological capability of the southern country. Given the patent length, generally each southern country tends to accept the northern patent protection if the market share and the life of the product are large, and in the opposite case patent protection is rejected, but depending on the parameter values there are situations where one southern country accepts patent protection while the other country rejects it. This possibility arises when the R&D innovation is less sensitive to patent protection by the marginal country. Moreover, depending on the curvature property of the invention function there are situations when the countries differ in respect of their patenting decision if their technological capability is of the intermediate level.

The paper is organized as follows. In the second section we present the model and results of the paper. In the third section we provide an illustration and discuss the results. Then follows a concluding section.

## 2. MODEL

We consider a framework of three countries, with one (technologically advanced) north, $N$, and two southern (developing) countries, $S_1$ and $S_2$. Only the north can innovate new products. However, the southern countries can imitate the innovated products, but after a finite period of time. We suppose that the north has provided patent protection to its innovators, and now it asks the rest of the world to honor its patent laws by extending similar protection to intellectual properties of the innovators for a finite period, $T$, $T < \infty$. Then $S_1$ and $S_2$ will unilaterally decide whether to honor $(H)$ the advanced country's patent laws or dishonor $(D)$ by rejecting the proposal. Knowing that its decision will affect the size of innovations, each southern country is to choose a policy decision from $\{H, D\}$.

Southern countries are assumed to be identical in terms of their imitating capabilities and market sizes. Let $\theta$ be the market share of each southern country in the integrated world demand. Then the market share of the north is given by $(1 - 2\theta) \geq 0$; therefore, $\theta \leq 1/2$. The imitating capability of the south is denoted by $\tau \geq 0$ which represents the length of the time period required by a southern country to imitate the technology embedded in the newly innovated products. Clearly, the case of interest is when $\tau < T$. If this does not hold, then not honoring the patent fails to qualify as a credible threat.

The northern innovation function is given by $r(R)$ where $r$ is the probability of a successful product invention if $R$ amount of resources are invested on R&D. We assume $r'(R) > 0$ and $r''(R) < 0$. Intuitively it is obvious, that is, an increase in the R&D expenditure undertaken will increase the probability of success at a decreasing rate. Further we assume that $r(0) \geq 0$, and $r(\infty) = 1$, that is, to attain a sure success in innovations the firm has to bear an infinitely high amount of R&D expenditure. To ensure interior solution we further assume that $r'(0) = \infty$ and $r'(\infty) = 0$.[2]

Let $\pi^m$ be the flow of monopoly payoff from the integrated world market. Therefore, the share of monopoly payoff from a country with market size $\theta$ is $\pi(\theta) = \theta\pi^m$. A country, by accepting patent protection, guarantees monopoly payoffs for the northern innovators for a period of $T$, whereas the firms can get monopoly payoffs at most for $\tau$ periods from a country which has dishonored patent protection. In either case, the market for the product turns out to be perfectly competitive, reducing the innovator's payoff to zero after the relevant time period.

Let us denote by $s^0$ and $s^m$ the per period flow of consumer surplus for each southern country under competitive condition and monopoly, respectively.[3] Since in our analysis discounting does not play any important role, except to keep the present value finite, we conveniently assume a zero discounting rate, but a definite date of obsolescence, $T'$, $T < T' < \infty$, for each innovation. So $T'$ is the life of the product which becomes

[2] As an illustration, a candidate qualifying for such an innovation function is $r = 1 - e^{-bR}$, $b > 0$. Since $r'(0) = b$ (constant), for interior solution we need to assume that $b$ is sufficiently large.

[3] If the integrated world demand be $P = a - Q$ where $P$ is price and $Q$ is quantity demand, then a southern country with $\theta$ market share has the demand function $P = a - Q/\theta$. Now if the cost of producing $Q$ is $cQ$, $c < a$, we have $s^0 = \theta(a - c)^2/2$ and $s^m = \theta(a - c)^2/8$.

obsolete beyond that time period. Since we are dealing with the decision problem of the south, we define the following concept of welfare, available in the event the good is consumed:

$$w(t) = ts^m + (T' - t)s^0 . \tag{1}$$

If the patent is honored for $t$ periods of time, then each southern country acquires the monopoly consumer surplus ($s^m$) for $t$ periods, and till the good becomes obsolete, the southern country gets the consumer surplus ($s^0$) as relevant under the competitive case. Clearly, the above payoff is materialised with the probability of success of the innovation; the south gets a payoff of zero with probability $(1 - r(R))$.

The game is as follows. In the first satge, both $S_1$ and $S_2$ simultaneously decide whether or not to honor northern patents. Then, given the scenario as emerged by the first stage decisions of $S_1$ and $S_2$, the northern firms in the second stage determine the optimal R&D expenditure and hence the corresponding probability of success of innovation. Therefore, while taking the first stage decision, each of the the southern countries internalizes the second stage behavior of the innovators. We concentrate on the first stage decision problem of the southern countries, and hence we consider the (subgame perfect) Nash equilibrium of the game.

Let $r_h$ be the probability of success corresponding to the optimal choice of $R$ by the northern firms when $h$ number of southern countries accept patent protection; $h = 0, 1, 2$. Hence,

$$\begin{aligned} r_0 &= r(R_0^*) \quad \text{where} \quad R_0^* = argmax_R \; r(R)[(1-2\theta)T + 2\theta\tau]\pi^m - R\,, \\ r_1 &= r(R_1^*) \quad \text{where} \quad R_1^* = argmax_R \; r(R)[(1-2\theta)T + \theta(T+\tau)]\pi^m - R\,, \\ r_2 &= r(R_2^*) \quad \text{where} \quad R_2^* = argmax_R \; r(R)[(1-2\theta)T + 2\theta T]\pi^m - R\,. \end{aligned}$$

One can then easily prove[4]

$$r_0 < r_1 < r_2 . \tag{2}$$

The result is shown in Figure 1. In panel (a) we have used the first order conditions of the above maximization problems to solve for the optimal values of $R$. Then, given the R&D function, panel (b) depicts the corresponding optimal innovation sizes, that is, the probabilities of success. Note that $r_2$ is independent of $\tau$, but $r_0$ and $r_1$ depend on $\tau$. When $\tau = T$, we have $r_2 = r_1 = r_0$. Then as $\tau$ falls, both $r_0$ and $r_1$ decrease.

Let $W_i(\alpha_1, \alpha_2)$ denote welfare of $S_i$ when its strategy choice is $\alpha_i$, $\alpha_i \in \{H, D\}$. Then for each possible decision of $S_1$ and $S_2$, given the behavior of the northern firms, the expected welfare levels of the southern countries are:

$$W_i(H,H) = r_2 w(T), \quad W_i(D,D) = r_0 w(\tau), \quad i = 1,2$$

$$W_1(H,D) = W_2(D,H) = r_1 w(T), \quad W_1(D,H) = W_2(H,D) = r_1 w(\tau) .$$

[4] Consider the innovation function as given in footnote 2 . To ensure interior solution we need $b > 1/((1-2\theta)T + 2\theta\tau)\pi^m$ . Then solving the maximization problem of the northern firms we shall get $r_0 = 1 - 1/b((1-2\theta)T + 2\theta\tau)\pi^m$, $r_1 = 1 - 1/b((1-2\theta)T + \theta(T+\tau))\pi^m$, and $r_2 = 1 - 1/bT\pi^m$.

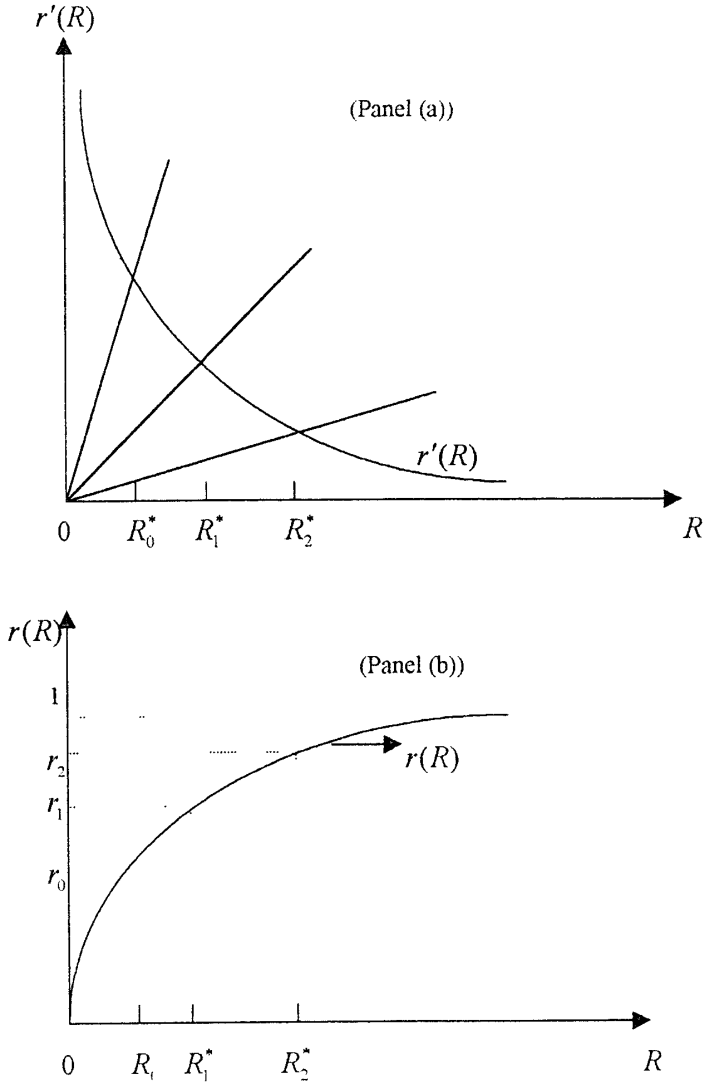


Figure 1. Determination of optimal innovation sizes.

Now define

$$K(\tau) = \frac{w(\tau)}{w(T)}. \tag{3}$$

Quite obviously, given (1), $K(\tau)$ is a decreasing (and linear) function of $\tau$ with $K(T) = 1$. We further define two functions $\frac{r_1}{r_0}$ and $\frac{r_2}{r_1}$, given (2)

Given this structure, we are now in a position to write the following proposition.

PROPOSITION 1. *Assume* $r_1^2 > r_0 r_2$. *Then given* $\tau$, (i) *if* $K < r_2/r_1$, *both the southern countries will honor northern patents*; (ii) *if* $K > r_1/r_0$, *both* $S_1$ *and* $S_2$

*will dishonor northern patents; and* (iii) *if* $r_2/r_1 < K < r_1/r_0$, *one of the southern countries will accept northern patent protection and the other country will reject it.*[5]

Proof of the proposition is given in the Appendix. In the following section we shall provide an illustration to show that indeed there are parametric situations where our results hold. We shall explain the conditions in terms of the primitives of the model. Note that the conditions underlying patenting decision of a country are entirely dependent on the factors like the patent length vis-a-vis the life of the product, the time required to imitate the technology by the south, the R&D technology of the innovators, and the parameters underlying the demand function.

To explain the result, consider first the case where the (subgame perfect) Nash equilibrium is $(H, H)$. Intuitively, if both countries choose to honor the patent, the northern firm has the added incentive of choosing a larger value of R&D expenditure, and hence correspondingly a larger value of the probability of success. The underlying condition (as given in Proposition 1(i)) states that if a decision on the part of the south to honor the patent comes with a proportional increase in the probability more than the critical value, $K$, then it is optimal for the south to honor. Since we have identical countries, the optimal behavior is just repeated by the other south. Similar explanation holds for $(D, D)$ to be the subgame perfect Nash equlibrium. If a movement towards choosing to honor comes with a proportional increase in the probability of success less than the critical value, $K$, then it is optimal for both the southern economies to dishonor the patent.

Our particular interest is in the situation where $(H, D)$ or $(D, H)$ can be a (subgame perfect) Nash equlibrium. Possibility of this case arises only when the assumption underlying the curvature of the innovation function holds, that is, $r_1/r_0 > r_2/r_1$. The assumption is quite intuitive. Our prior restriction on the innovation function is that the probability of success is increasing at a decreasing rate. In addition, we require that proportional increase in the probability of success will also be falling as more and more countries extend patent protection. Given that one country has accepted patent protection, the marginal country finds that if it accepts similar protection, the expected increase in benefits (probability) is not large enough to compensate for the corresponding deadweight loss, given its imitating capability. Quite obviously, if the above inequality would be reversed, then under this situation the marginal country would find it profitable to extend similar protection. Hence our analysis shows that the sensitivity of innovation with respect to extending patent protection is an important factor for the southern countries to decide their optimal strategy.

[5] If $r_1^2 \leq r_0 r_2$, the equilibrium decisions of the southern countries will be either $(H, H)$ or $(D, D)$, that is, in this case the interests of the southern countries will match.

## 3. ILLUSTRATION AND ANALYSIS

In this section we argue that none of the results stated in Proposition 1 is empty in the sense that there are parametric situations when the underlying conditions of the proposition hold, hence we explain the results in terms of the primitives of the model.

First, note that at $\tau = T$, we have $K = 1$ and $r_2 = r_1 = r_0$ so that $\frac{r_i}{r_j} = 1,\ i \neq j$. Then as $\tau$ falls, $K$ goes up and both $r_0$ and $r_1$ decrease. But in general it is not clear what happens to the relative size of $K$ and $\frac{r_2}{r_1}$, although both quantities increase when $\tau$ falls. Moreover, the direction in change of $\frac{r_1}{r_0}$ is not known apriori. A mild restriction may, however, make the function falling.

Secondly, the curvatures of the ratio (i.e., $r_1/r_0$ and $r_2/r_1$) functions involve the term $r'''$ about which we don't have any apriori restriction. Therefore, theoretically these functions can be concave, convex or any other shape.[6] Below we provide an example which generates (strictly) convex ratio functions with having some desired properties.

Ler the R&D production function be

$$r(R) = \frac{2R^{1/2}}{\alpha} \quad \text{with} \quad \alpha > 0 \quad \text{and} \quad 0 \leq R \leq \frac{\alpha^2}{4}\,. \tag{4}$$

Then $r_0$, $r_1$ and $r_2$ can easily be solved as:

$$r_0 = \frac{2A_0\pi^m}{\alpha^2}\,, \quad r_1 = \frac{2A_1\pi^m}{\alpha^2}\,, \quad \text{and} \quad r_2 = \frac{2A_2\pi^m}{\alpha^2} \tag{5}$$

where

$$A_0 = (1-2\theta)T + 2\theta\tau,\ A_1 = (1-2\theta)T + \theta(T+\tau),\ \text{and}\ A_2 = (1-2\theta)T + 2\theta T = T\,.$$

From (5),

$$\frac{r_1}{r_0} = \frac{A_1}{A_0} \quad \text{and} \quad \frac{r_2}{r_1} = \frac{A_2}{A_1}\,. \tag{6}$$

The important properties of these ratio functions are the following.[7]

$$\text{Both } \frac{r_1}{r_0} \text{ and } \frac{r_2}{r_1} \text{ are decreasing and strictly convex in } \tau \text{ with } \frac{r_1}{r_0} > \frac{r_2}{r_1} \quad \forall \tau < T\,. \tag{7}$$

Let us define $T' = \rho T$ and $s^m = \beta s^0$ where $\rho > 1$ and $0 < \beta < 1$. So larger $\rho$ implies that the product under our consideration lives for a longer period after the patent is expired. With the assumption of linear market demand and constant returns to scale technology we have $\beta = 1/4$ (see footnote 3). Then,

$$K(0) = \frac{\rho}{\rho - (1-\beta)}\,, \quad \frac{r_1}{r_0}(0) = 1 + \frac{\theta}{1-2\theta}\,, \quad \frac{r_2}{r_1}(0) = \frac{1}{1-\theta}\,.$$

6 For instance, the possibility of $r_2/r_1$ function being concave arises only when $r'''$ is positive and is very large.

7 Given (4), we have $\frac{d(\frac{r_1}{r_0})}{d\tau} = -\frac{\theta T}{A_0^2} < 0$, $\frac{d^2(\frac{r_1}{r_0})}{d\tau^2} = \frac{4\theta^2 T}{A_0^3} > 0$, $\frac{d(\frac{r_2}{r_1})}{d\tau} = -\frac{\theta T}{A_1^2} < 0$, $\frac{d^2(\frac{r_2}{r_1})}{d\tau^2} = \frac{2\theta^2 T}{A_1^3} > 0$, and $\frac{r_1}{r_0} - \frac{r_2}{r_1} = \frac{\theta^2(T-\tau)^2}{A_0 A_1} > 0$.

Also

$$K'(T) = -\frac{1-\beta}{T(\rho-(1-\beta))}, \quad \frac{d(\frac{r_1}{r_0}(T))}{d\tau} = \frac{d(\frac{r_2}{r_1}(T))}{d\tau} = -\frac{\theta}{T}.$$

We are now in a position to discuss the results of Proposition 1 in terms of the parameters of the model keeping in mind the properties of $r_1/r_0$, $r_2/r_1$ and $K$ functions.

*Case* 1: *Both the southern countries honor northern patent protection*

From Proposition 1, this case arises when $K < \frac{r_2}{r_1} < \frac{r_1}{r_0}$. Now given the properties of the ratio functions (see (3) and (7)), we must have $K < \frac{r_2}{r_1} < \frac{r_1}{r_0} \quad \forall\tau < T$ if $|\frac{d(\frac{r_2}{r_1}(T))}{d\tau}| > |K'(T)|$, that is, if

$$\theta > \frac{1-\beta}{\rho-(1-\beta)}. \tag{8}$$

This will be satisfied if $\theta$ and $\rho$ take relatively larger values; this means, we need that the southern market will not be too small and at the same time the product should survive for a longer period after the patent is expired. For instance, given $\beta = 1/4$, since $\theta \leq 1/2$, condition (8) implies $\rho > 1.5$.

*Case* 2: *Both the southern countries reject northern patent protection*

This becomes an equilibrium decision when $K > \frac{r_1}{r_0} > \frac{r_2}{r_1}$. Given the properties of the functions, this is necessarily satisfied for all $\tau$ if $K(0) > \frac{r_1}{r_0}(0)$. This leads to the condition

$$\frac{\theta}{1-2\theta} < \frac{1-\beta}{\rho-(1-\beta)}. \tag{9}$$

Hence (9) is satisfied for small values of $\theta$ and $\rho$. For instance, given $\beta = 1/4$, if $\theta = 1/3$ we need $1 < \rho < 1.5$.

*Case* 3: *One southern country accepts patent protection and the other rejects*

This possibility arises when $\frac{r_1}{r_0} > K > \frac{r_2}{r_1}$. Consider the parametric situation $\frac{r_1}{r_0}(0) > K(0) > \frac{r_2}{r_1}(0)$, that is,

$$\frac{\theta}{1-2\theta} > \frac{1-\beta}{\rho-(1-\beta)} > \frac{\theta}{1-\theta}. \tag{10}$$

When (10) holds, we have also $|\frac{d(\frac{r_1}{r_0}(T))}{d\tau}| < |K'(T)|$. Therefore,

$$\exists\ \tau^* \,|\, \frac{r_1}{r_0} > K > \frac{r_2}{r_1} \quad \forall\tau < \tau^*.$$

Hence when (10) holds and at the same time $\tau < \tau^*$, one southern country honor northern patent protection while the other will dishonor. As the condition (10) shows, the possibility of this situation arises when $\rho$ takes an intermediate value, given $\theta$. For example, if $\theta = 1/3$, we have $1.5 < \rho < 2.25$.

So far we have illustrated the case when the ratio functions are convex. But as we have already mentioned, there can be situations when these ratio functions will be concave.

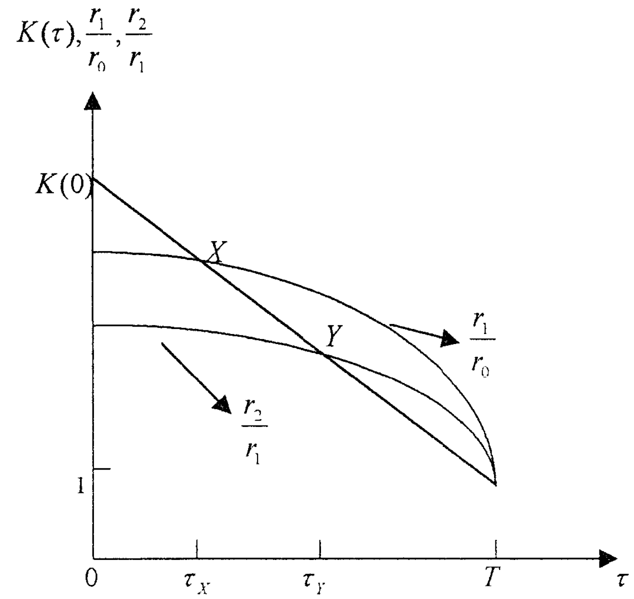


Figure 2. Patenting decision under assumption A.

This possibility arises when $r'''$ is positive and it takes a very large value.[8] Under this curvature assumption we show that patenting decision of a southern country crucially depends on its imitative capability. Consider the scenario as described by the following assumption.

ASSUMPTION A. Let $r(R)$ function be such that both $\frac{r_2}{r_1}$ and $\frac{r_1}{r_0}$ are decreasing and concave in $\tau$ with the following characteriztion:

$$\text{(i)}\ \frac{r_1}{r_0} > \frac{r_2}{r_1}\ \forall \tau < T\,, \quad \text{(ii)}\ K(0) > \frac{r_1}{r_0}(0)\,, \quad \text{and} \quad \text{(iii)}\ K'(T) > \frac{d(\frac{r_2}{r_1})(T)}{d\tau}.^9$$

Part (i) of the above assumption is already explained while explaining Proposition 1; part (ii) of the assumption is likely to hold for small $\theta$ and $\rho$ (see Case 2 above); and part (iii) follows from the curvature assumption. Therefore, given the parametric situations as described by assumption A, the functions $\frac{r_1}{r_0}$ and $\frac{r_2}{r_1}$ will intersect the $K(\tau)$ line from below at points $X$ and $Y$ respectively. These two points correspond to two critical levels of $\tau$ as $\tau_X$ and $\tau_Y$ such that $K > \frac{r_1}{r_0}$ for $\tau < \tau_X$, $K < \frac{r_2}{r_1}$ for $\tau > \tau_Y$, and $\frac{r_2}{r_1} < K < \frac{r_1}{r_0}$ for $\tau_X < \tau < \tau_Y$. This is portrayed in Figure 2. This leads to an interesting corollary of Proposition 1.

8 $\frac{d^2(\frac{r_2}{r_1})}{d\tau^2} = \frac{\theta r_2}{[r_1^2 r_1'' A_1]^2}[2r_1^2 r_1' (r_1'')^2 A_1 \frac{dR}{d\tau} - (r_1')^2\{r_1^2 r_1'' A_1' + r_1^2 A_1 r_1''' \frac{dR}{d\tau} + 2r_1 r_1' r_1'' A_1 \frac{dR}{d\tau}\}].$

9 In fact, $\frac{d(\frac{r_2}{r_1})(T)}{d\tau} = \frac{d(\frac{r_1}{r_0})(T)}{d\tau}$.

COROLLARY 1. *Given the parametric scenario as described by assumption A, if the imitating capability of the south is of middle level, in the subgame perfect equilibrium one southern country will accept foreign patent protection while the other country will reject it. If the imitative capability is of high order, "dishonor" will be the equilibrium decision of each southern country, and if the imitating capability is low, "honor" is the equilibrium decision.*

A lower value of $\tau$ provides the south with an option to adapt to the technology quickly and hence accounts for the disincentive to honor the northern patent. Similarly, if $\tau$ is high, that is, if the imitating capability of the south is low, by accepting foreign patent protection each country can enhance the size of the innovation and can avoid the potential loss of welfare. Therefore, when $\tau$ is of intermediate level, given the curvature assumption, one country finds it profitable not to accept foreign patent protection when the other country accepts it. The reason is that the marginal country cannot increase the probability of success sufficiently and hence it finds free riding more profitable.

## 4. CONCLUSION

The protection of intellectual property rights across countries is one of the few thorny issues that have rocked both the northern and southern countries in the recent years. The present paper seeks to point out that the problem of international patent protection is much deeper, far beyond the north-south connotation. In our simple structure we have shown that even when the southern countries are identical in all respect, their patenting decisions may differ. There is an incentive for each country to free ride on the other accepting patent protection, and hence they might conflict each other at an international forum like the GATT. A country by giving protection increases the size (probability) of innovations, but at the same time it suffers from the added deadweight loss. Hence there is a trade off. Generally, if the southern countries have relatively larger domestic markets, they tend to accept the northern patent protection and in the opposite case they reject it. However, when the R&D innovation function is less sensitive to patent protection by the marginal country, there are parametric situations for which one country accepts patent protection, and for the other country not to give protection is optimal. We have demonstrated that the patenting decision of a country hinges on the parameters like the imitating capability, the sensitivity of the innovation technology, the life of the product vis-a-vis the patent length, etcetera. We have derived the results on the assumption that all southern countries are identical. In the real world countries differ in respect of one or the other characteristic. Then the chance of a matching decision gets further weakened.

## APPENDIX

PROOF OF PROPOSITION 1. The payoffs of the southern countries are given in the following matrix:

| | $H$ | $D$ |
|---|---|---|
| $H$ | $r_2w(T), r_2w(T)$ | $r_1w(T), r_1w(\tau)$ |
| $D$ | $r_1w(\tau), r_1w(T)$ | $r_0w(\tau), r_0w(\tau)$ |

Given the payoffs of $S_1$ and $S_2$, $(H, H)$ will be a Nash equilibrium iff the following inequalities hold simultaneously, i.e., $W_1(H, H) > W_1(D, H)$ and $W_2(H, H) > W_2(H, D)$. These together give the condition $K < r_2/r_1$. Similarly, $(D, D)$ is a Nash equilibrium iff $W_1(D, D) > W_1(H, D)$ and $W_2(D, D) > W_2(D, H)$, which together imply the inequality $K > r_1/r_0$.

For $(H, D)$ to be a Nash equlibrium we need to satisfy $W_1(H, D) > W_1(D, D)$ and $W_2(H, D) > W_2(H, H)$ and for $(D, H)$ to be a Nash equlibrium we must have $W_1(D, H) > W_1(H, H)$ and $W_2(D, H) > W_2(D, D)$. In either case, combining two inequalities we have $r_2/r_1 < K < r_1/r_0$. [QED]

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