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Patent Protection in a North-South Framework: A Simple Model*

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Abstract

We show that under some conditions it is optimal for the non-innovating south to give patent protection for a longer period than the innovating north. However, a cooperative patent agreement involves a larger protection by each country compared to the non-cooperative situation.

Keywords: Patent protection; innovation; cooperative agreement.

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1. Introduction

The issue of protecting intellectual properties across national boundaries has been one of the most contentious issues and has received wide attention lately. After much controversy the Trade Related Intellectual Property Rights (TRIPs) accord was incorporated in the Uruguay round of GATT. It requires all the signatory countries to give patent protection to all new innovations, irrespective of their country of origin. The minimum duration of patent protection (patent length) was set at 20 years for most products. The TRIPs proposal was backed by the argument that a wider protection of intellectual property would lead to a *Pareto improvement* in the sense that countries which extend protection will eventually gain in net terms from an increased flow of innovations that such a system will bring about. It was also pointed out that it is *ethically* unjust to steal rents from innovators, and wider patent protection will promote innovative activity leading to faster technological progress. The developing countries, on the contrary, feared that this would create substantial distortion in their domestic market and lead to increased prices for essential items such as pharmaceuticals. They viewed this accord as an instrument by which the developed nations would try to capture their markets.

The importance of intellectual property rights (IPR) protection in a north-south framework has already made its way to the academic encyclopedia. Papers by Chin and Grossman (1991), Maskus (1990), Diwan and Rodrik (1991), Deardorff (1992), Aoki and Prusa (1993), Helpman (1993), Taylor (1994), Yang (1998), and Kabiraj and Banerjee (2002), among others, address the issue of IPR protection in the north-south framework.[1] But none of these papers addresses the issue of optimal patent length in this framework.

In this paper we develop a north-south model where products developed in the north can be costlessly imitated in the south. The innovation we consider is 'endogenous' in the sense that patent protection given in the south affects the innovation size in the north.[2] In our structure where innovations are endogenous, there is a trade-off for the

[1] There is a sizeable literature on technology transfer and patent protection. For instance, see Vishwasrao (1994) and Fosfuri (2000).

[2] It is possible to identify at least a few innovations that may be generated in the north even if the southern countries do not extend patent protection. The large size of the northern markets makes these innovations viable. These are familiarly known as 'exogenous' innovations and are unaffected by the extent of patent protection offered in the south. Generally, the dominant strategy of the south in such a case is to extend no protection to such innovations. Still there can be situations where extending patent protection will be the optimal decision for the south (Kabiraj (2000)).

southern country government regarding patent protection to northern innovations. On the one hand, increased protection means greater market distortion and lower social welfare. On the other hand, greater protection will lead to an increase in the size of northern innovations leading to an increase in southern welfare. In this setting we address the issue of optimal patent length in the developed north vis-à-vis the developing south.[3] We show that when the countries confer patent protection non-cooperatively, under certain conditions the optimal patent length conferred by the southern country will be greater than that of the northern country. We further show that welfare in each country can be enhanced by departing from the non-cooperative equilibrium and appropriately increasing the patent length in both the countries through a binding contract signed by the respective government (a cooperative solution). This brings to the forefront the importance of international patent agreements that lead to enhanced global welfare.

The present work adopts the framework of Ghosh and Kabiraj (2005) that also considers an interaction between two country governments and two firms. In Ghosh and Kabiraj, however, both country firms are capable of doing research, whereas in the present paper only the north can innovate.

The rest of the paper is organized as follows. In section 2 we set up the model. Section 3 deals with the case where both the north and the south confer patent protection non-cooperatively. We then bring the possibility of cooperation in this framework.

2. Model

Consider strategic interaction between two countries, one representative northern country and one representative southern country. In such a framework each country government is concerned about maximizing the social surplus, whereas the R&D firms attempt to maximize the total expected return from innovations. We assume that all innovations take place only in the north; southern firms, however, imitate the northern innovations

[3] The other dimension of patent protection is patent breadth or patent scope. Patent length refers to the time interval over which the patent holder is entitled to monopoly power. Patent breadth has different interpretations (Gilbert and Shapiro (1990) and Klemperer (1990)). It generally refers to how close a product shouldn't be so that it does not infringe the other producers' innovations. In this paper, however, we abstract away from the patent breadth aspect.

once the northern firms export their goods to the south.[4] We assume product innovation and that when the product is developed successfully, it is produced at a constant marginal cost.

Let us now define the following scalars. Let $\alpha_i \Pi^m$ denote the post-innovative flow of monopoly rent or profit from the i[th] market, $\alpha_i S^m$ is the flow of consumers' surplus when the market is served by the monopolist, and $\alpha_i S^c$ is the total social surplus (which would be entirely in the form of consumer surplus) that would arise per period if the market be competitive, operating by a marginal cost pricing rule. Let $i = 1$ denote north and $i = 2$ denote south. Finally, α_i is the country specific factor representing the market size of the country concerned. Naturally, we have $S^c > S^m + \Pi^m$ due to the familiar dead-weight loss created in the monopolistic market.

We set the model in continuous time, and r is the rate of time discount taken to be the same for everyone. The government in country $i\,(i = 1,2)$ decides a patent length T_i, to which it commits by passing a patent law. When the (northern) innovating firm is successful in developing the new product, it will have the exclusive right to market the good for the time length T_i in market i and earn a flow of monopoly profit $\alpha_i \Pi^m$ in that market. After the patent expires, any firm can imitate the product without any cost, and the market becomes perfectly competitive so that the profit of each firm drops to zero from that point onwards.[5]

We assume that research outcomes are uncertain and that research venture requires costly resources. It is natural to assume that more the northern firm spends on R&D, the greater is the probability that the innovative activity will end up with a successful outcome. Let R denote the amount of resources devoted to R&D. Then $\rho(R)$ is the probability of success of the innovative activity. We make the following assumption:

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[4] This assumption is taken almost for granted in the literature and also has some empirical justification. The world patent statistics show that that the developing countries as a whole own a very insignificant portion of the existing patents (for instance, see Braga (1990) and Dunning (1994)).

[5] If there is a finite number of firms, we may then assume Bertrand competition so that profits of each firm fall to zero.

Assumption 1: *The R&D function* $\rho(R)$ *is twice continuously differentiable, with the following properties,* $\rho'(R) > 0$, $\rho''(R) < 0$, $\rho(0) = 0$, $\rho(\infty) = 1$, $\rho'(0) = \infty$, $\rho'(\infty) = 0$.

The above properties are pretty simple. As more and more resources are devoted to the research activity, the probability of success increases but at a diminishing rate. When no resource is devoted, then failure is a sure event. The last two are the familiar Inada type conditions imposed to ensue interior solutions.

3. Choice of Patent Lengths

Consider the case where the governments choose their respective patent lengths maximizing their own welfare. The decision making process essentially constitutes a two stage game – in the first stage both governments simultaneously and independently choose their respective patent lengths, while in the second stage the northern innovator decides its optimal R&D investment. We solve for the sub-game perfect equilibrium of this game. Obviously, the optimal R&D level of the northern firm will depend on the patent length conferred by its country as well as on the patent protection extended by the southern country. The expected payoff can be written as

$$\Phi = \rho(R)\left[\int_0^{T_1} e^{-rt}\alpha_1\Pi^m dt + \int_0^{T_2} e^{-rt}\alpha_2\Pi^m dt\right] - R$$

$$= \frac{\rho(R)}{r}\left[\left(1-e^{-rT_1}\right)\alpha_1\Pi^m + \left(1-e^{-rT_2}\right)\alpha_2\Pi^m\right] - R \tag{1}$$

Assumption 1 guarantees that for all positive values of T_i, the objective function is strictly concave and the maximizing problem has a unique interior solution.

To economize on notation, we make the following substitution: $\lambda_i = \left(1-e^{-rT_i}\right)$, i = 1, 2. It can be easily seen that searching for a $T_i \in [0,\infty]$ is equivalent to searching for a $\lambda_i \in [0,1]$. Thus from now on we will search for λ_1 and λ_2 within [0,1].

Then, the first order condition of the firm's maximization problem is

$$\frac{\rho'(R)}{r}\Pi^m\left[\alpha_1\lambda_1 + \alpha_2\lambda_2\right] = 1 \tag{2}$$

This solves for an optimal R^* as a function of λ_1 and λ_2, that is,

$$R = R^*(\lambda_1, \lambda_2) \tag{3}$$

It can be easily checked that the function is monotonically increasing in λ_i, the larger the patent protection, the larger is the gain from a successful innovation, and hence the greater will be the resources allocated to R&D activity. Formally, we have

$$\frac{\partial R}{\partial \lambda_i} = \frac{-r\alpha_i}{\rho''(R)[\alpha_1\lambda_1 + \alpha_2\lambda_2]^2} > 0 \text{, given } \rho''(R) < 0 . \tag{3a}$$

We cannot, however, say anything in general about the curvature of the function $R^*(\lambda_1, \lambda_2)$. We assume for the rest of our analysis that the function is strictly concave in λ_i.[6]

Next we turn to the first stage of the game in which the two governments simultaneously choose their respective patent lengths. Each government's problem can be formulated as shown below. The northern government will choose λ_1 to maximize its total welfare[7]

$$W^N(\lambda_1, \lambda_2) = \frac{\rho(R)}{r}\left[\alpha_1 S^m \lambda_1 + \alpha_1 S^c(1-\lambda_1) + \alpha_1 \Pi^m \lambda_1 + \alpha_2 \Pi^m \lambda_2\right] - R^*(\lambda_1, \lambda_2) \tag{4}$$

subject to the constraint $R = R^*(\lambda_1, \lambda_2)$. The above expression represents a utilitarian social welfare function with equal weights on producer and consumer surplus. It can be noted that we implicitly assume that the innovating northern firm doesn't spend anything in the southern country and thus all the producer surplus goes to the northern country's welfare.[8] Maximizing (4) with respect to λ_1 subject to $R = R^*(\lambda_1, \lambda_2)$ yields the following first order condition,

$$\rho(R) = \frac{\left[S^m \lambda_1 + (1-\lambda_1)S^c\right]}{\left(S^c - S^m - \Pi^m\right)} \rho' \frac{\partial R}{\partial \lambda_1} \tag{5}$$

This yields the response function $\lambda_1 = f(\lambda_2)$. On the other hand, the southern country will choose λ_2 to maximize its domestic social welfare

$$W^S = \frac{\rho(R)}{r}\left[\alpha_2 S^m \lambda_2 + \alpha_2 S^c(1-\lambda_2)\right] \tag{6}$$

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[6] The function is definitely concave if $\rho''' < 0$.

[7] We assume W^N to be strictly concave. This holds if $R^*(\lambda_1, \lambda_2)$ is concave in λ_1 but not too concave.

[8] There are umpteen examples where the MNCs produce only in some countries, but sell its product across the globe. It does not necessarily have production plants in all the countries it operates.

subject to the constraint $R = R^*(\lambda_1, \lambda_2)$. The corresponding first order condition is

$$\rho(R) = \frac{\left[S^m \lambda_2 + (1-\lambda_2) S^c\right]}{\left(S^c - S^m\right)} \rho' \frac{\partial R}{\partial \lambda_2} \tag{7}$$

This generates the response function $\lambda_2 = f(\lambda_1)$. The solution to these response functions derived from (5) and (7) defines the sub-game perfect equilibrium of the whole game. This leads to our first proposition:

Proposition 1: *Given that both the countries confer patent protection non-cooperatively, the optimal patent length conferred by the south will be greater than that conferred by the north iff* $\alpha_1 < \alpha_2 A$, *where* $A = \frac{\left(S^c - S^m - \Pi^m\right)}{\left(S^c - S^m\right)} < 1$.

For a formal proof see the appendix. The result can be explained as follows. When the southern country government confers patent protection to the northern innovation, the two opposing effects are working. One is the 'direct effect' of increasing patent length on southern welfare, which is negative. The other is the favorable 'indirect effect', which may be referred to as the '*innovation size effect*'. As the south increases patent protection to northern innovations, the incentive to invest more in R&D activity increases. This increased investment increases the probability of R&D success that in turn increases the welfare of the south. The southern country government confers patent protection for that length for which its social welfare is maximized. This therefore requires that the incremental positive 'innovation size effect' is exactly equal to the negative 'market concentration effect'. All these effects crucially depend on the market size of the respective countries. Thus for a sufficiently larger market size it is optimal for the south to give protection for a longer period.

Corollary: *If the countries have equal market size (i.e.* $\alpha_1 = \alpha_2$*), the optimal patent length conferred by the northern country government will be greater than that conferred by the southern country government.*

One feature of the above equilibrium immediately becomes apparent. There are always positive spillovers in the game between policy-making authorities. This is because part of the benefits of encouraging research in the northern country accrues to the consumers of the south. This benefit is not fully internalized by the northern country government while granting patent protection. The same applies for the southern country also. Thus, in both countries, the choice of patent length under non-cooperative situation tends to be ‘too short’ for efficiency. From this argument arises the possibility of cooperation between the northern and southern countries to accept a universally recognized patent policy such that the global welfare is enhanced. We have the following proposition (see *Appendix* for the formal proof).

Proposition 2: *Patent lengths conferred by each of the northern and southern countries in a cooperative equilibrium are larger compared to the non-cooperative situation.*

Our result clearly establishes a case for an international patent agreement. This reinforces the rationale for the existence of a global planner (like the WTO) maximizing global welfare in such a way that no country is worse off and at least one country is better off.

In reality, the major point of discord arises over the distribution and transferability of the maximized global welfare. Hence, one meaningful extension of the present work should be to study the case where welfare is non-transferable. Within the structure it may also be interesting to see whether a uniform patent protection can be a candidate for equilibrium.

4. Conclusion:

This note has focused on the contentious issue of the Intellectual Property Rights protection and discussed in a north-south framework the question of the optimum patent lengths. We show that in this non-cooperative equilibrium the non-innovating south in its interest might confer patent protection for a longer time period than the innovating north. We have also examined whether there are patent agreements that will be mutually beneficial to both countries. We show that there always exist patent agreements for which both countries are better off. Specifically we show that a cooperative patent agreement involves a larger protection by each country compared to the non-cooperative situation. This justifies, to some extent, the rationale for the existence of a central body like the WTO in determining patent lengths in such a way that global welfare is maximized.

APPENDIX

Proof of Proposition 1:

From equations (5) and (7) we get

$$\frac{\frac{\partial R^*}{\partial \lambda_1}}{\frac{\partial R^*}{\partial \lambda_2}} = \frac{\left[S^m\lambda_2 + S^c(1-\lambda_2)\right]}{\left[S^m\lambda_1 + S^c(1-\lambda_1)\right]} \times \frac{\left(S^c - S^m - \Pi^m\right)}{\left(S^c - S^m\right)} \tag{A1}$$

The optimal $\lambda_1{}^*$ and $\lambda_2{}^*$ must satisfy the above equilibrium condition.

Using (3a), equation (A1) simplifies to

$$\frac{\left[S^m\lambda_2 + S^c(1-\lambda_2)\right]}{\left[S^m\lambda_1 + S^c(1-\lambda_1)\right]} = \frac{\alpha_1}{\alpha_2} \times \frac{1}{A}, \text{ where } A = \frac{\left(S^c - S^m - \Pi^m\right)}{\left(S^c - S^m\right)} < 1.$$

If $\alpha_1 < \alpha_2 A$, we get $\frac{\left[S^m\lambda_2 + S^c(1-\lambda_2)\right]}{\left[S^m\lambda_1 + S^c(1-\lambda_1)\right]} < 1$.

Further simplification yields $\left(S^c - S^m\right)\lambda_2 > \left(S^c - S^m\right)\lambda_1 \Rightarrow \lambda_2 > \lambda_1$, since $\left(S^c - S^m\right) > 0$; otherwise $\lambda_1 > \lambda_2$. ■

Proof of Proposition 2:

Pareto optimality requires that the global welfare be maximized. Put technically, it implies that

$$\frac{\partial W^N}{\partial \lambda_1} + \frac{\partial W^S}{\partial \lambda_1} = 0 \quad \text{and} \quad \frac{\partial W^N}{\partial \lambda_2} + \frac{\partial W^S}{\partial \lambda_2} = 0.$$

In the non-cooperative equilibrium each government's choice must be a best response, and therefore, $\frac{\partial W^N}{\partial \lambda_1} = 0$ and $\frac{\partial W^S}{\partial \lambda_2} = 0$. However, from the payoff functions we have $\frac{\partial W^S}{\partial \lambda_1} > 0$ and $\frac{\partial W^N}{\partial \lambda_2} > 0$. Thus, under Pareto optimality we must have $\frac{\partial W^S}{\partial \lambda_2} < 0$ and $\frac{\partial W^N}{\partial \lambda_1} < 0$. Since W^N and W^S are concave in λ_1 and λ_2, we get $\lambda_i{}^C > \lambda_i{}^{NC}$ where the superscripts stand for 'cooperative' and 'non-cooperative' respectively. ■

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