Harmonization of Patent Protection

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I. Introduction

The process of economic integration has expanded beyond the simple elimination of trade barriers between countries to encompass the coordination of market rules. A prime example of this is the incorporation of the Trade-Related Intellectual Property (TRIPs) agreement into the World Trade Organization. Under the TRIPS agreement, member countries have to meet minimum standards for laws governing the the protection of patents, copyrights, and a variety of other forms of intellectual property. Furthermore, they have agreed to provide domestic mechanisms for the enforcement of protection of intellectual property.

One of the interesting features of the TRIPS is its setting of minimum standards for protection for intellectual property which are often quite close to the levels that are observed in developed countries. This has resulted in a substantial increase in the level of protection provided in developing countries, and could potentially lead to a substantial transfer of income from non-innovating to innovating countries.[1] This has raised the question of whether it is appropriate to impose rich country standards of intellectual property protection on poor, non-innovating countries. Grossman and Lai (2002) have developed a model of the setting of standards for intellectual property in which the level of innovation depends only on the total world-wide protection provided. Thus, an efficient level of innovation could equally well be provided by short patent lives in the South and long lives in the North as by a system that harmonizes patent lives between North and South. This suggests that the primary effect of harmonization of standards is redistributive.

An important feature of the Grossman-Lai model is the assumption that markets can be completely segmented, so that patent lives of different lengths can be maintained without arbitrage between markets. In this paper we examine the incentives for harmonization of patent lives when there is a potential for arbitrage between a market where patent protection has expired and one where the patent

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[1]McCalman (2001) estimates the net transfers under the TRIPS agreement for 29 (primarily developed) countries and finds that only 6 of the countries are net gainers from the agreement. He finds that the US is the primary beneficiary of the TRIPS agreement, with a gain that is almost 6 times that of the next largest gainer.

is still in effect.   The recent debate In addition to choosing patent lives, countries with longer patent lives may also devote resources to reducing the amount of arbitrage that goes on between markets.

We examine how the existence of arbitrage affects the incentives for countries in the setting of patent lives under the assumptions that governments choose policies to maximize national welfare. We first examine the Nash equilibrium patent protection levels, which arise in the absence of international agreements between countries on patent levels.   We show that the existence of arbitrage makes it more attractive for non-innovating countries to extend their patent protection. We also show that the innovating country will not provide complete protection of monopoly profits for firms when patents expire in non-innovating countries. A small inflow of goods from the market where the patent has expired will reduce the deadweight loss due to monopoly without eroding the incentive of firms to innovate.

Finally, we characterize efficient agreements between countries. We first show how the efficient levels differ from the Nash equilibrium levels due to the static and dynamic spillovers between countries resulting from protection of intellectual property. We then show that rather than creating an incentive to harmonize patent lives, the existence of arbitrage will generally result in efficient agreements in which differences in patent levels across countries reduces the deadweight loss associated with the patent system.

II. A Model of Intellectual Property Rights with Spatial Arbitrage

In this section we consider a simple North/South model of intellectual property rights in which the home country (North) has the ability to innovate new products whereas the foreign (South) can only imitate. As in Deardorff (1992) and Scotchmer (2002) a two period model of innovation. In the first (innovation) period, the home country firms choose how much to invest in the development of differentiated products. In the second (production) period, innovating firms produce the differentiated product. The length of the production period corresponds to the (exogenously given) useful life of a

brand in the differentiated product sector.

It is assumed there are two sectors, a homogeneous good sector and a differentiated product sector. In the first period, home firms choose the amount of innovation to undertake in the development of a differentiated products in the first period, which will determine the number of varieties of the product that will be available in the second period. The preferences of consumers during the production period are given by $\int_0^T \left(\int_0^N u\left(d_t(\omega) \right) d\omega + z_t \right) e^{-\rho t} dt$, where T is the length of the production period, ω is the index of the differentiated products, $d_t(\omega)$ is consumption of differentiated product ω at time t during the production period, and z_t is consumption of the standardized good. Choosing the homogeneous good as the numeraire, this yields a demand function for a differentiated product at time t of $d_t(\omega) = d(p_t(\omega))$ where $d \equiv (u')^{-1}$. The indirect utility function can then be written as

$$U = \int_0^T \int_0^N s\left(p(\omega)_t \right) e^{-rt} d\omega \, dt + Y \tag{1}$$

where $s(p) \equiv u(d(p)) - p\, d(p))$ is the consumer surplus associated with a representative differentiated product and Y is the present value of income during the production period. Similarly, we can define home demand and consumer surplus, $d^*(p)$ and $s^*(p^*) \equiv u^*(d^*(p^*)) - p^* d^*(p^*))$.

Units are chosen such that production of the homogenous good requires 1 unit of labor. Since the homogeneous good is competitively produced, the home wage will also equal 1. Production of a unit of the differentiated brand requires c units of labor in the home country. An innovating firm in the home country is assumed to be granted a monopoly in the production of its brand of the differentiated product for a length of time τ (τ^*) $\in$ [0, T] in the home (foreign) market. It will be assumed that markets are imperfectly segmented, in the sense that an arbitrager attempting to profit from a price differential

between markets will have a probability λ of having the goods confiscated by the government. Therefore, prices must be set subject to the constraint that $(1 - \lambda)\max(p_t, p_t^*) \leq \min(p_t, p_t^*)$, where λ will reflect the level of resources devoted by the government in the high price location to preventing arbitrage.[2]

In the absence of arbitrage constraints, the innovating firm would set the monopoly price in each market in any time period in which the patent is still in effect in the market. The potential arbitrage profits arise from two possibilities. The first is that the firm is price discriminating across markets during a period when patents are in effect in both markets. The second occurs when the patent lives differ across markets, so that the price will drop to the competitive level in only one market when the patent expires in one market. Since the emphasis in this paper is on the impact of differential patent lives across markets, we will abstract from the first arbitrage issue by assuming that monopoly price in each market is the same. The simplest way to do this is to simply assume that the two markets differ only in scale, $d^*(p) = \psi d(p)$ and $s^*(p) = \psi s(p)$, where ψ denotes the relative size of the foreign country market.[3] The profit function for the home market can be denoted $\pi(p)$, with $\pi^*(p) = \psi\pi(p)$. It will be assumed that $\pi(p)$ is strictly concave on $[0,c]$, with p_M denoting the monopoly price and $\pi(c) = 0$.

In formulating the payoffs it will be assumed that $\tau \geq \tau^*$. The conditions under which this will hold in the Nash equilibrium will be discussed below. With these assumptions, $p_t(\omega) = p_t^*(\omega) = p_M$ for t $< \tau$ and $p_t(\omega) = p_t^*(\omega) = c$ for $t > \tau$. For $t \in (\tau^*, \tau]$, $p_t^*(\omega) = c$ and $p_t = p(\lambda) \equiv \min(c/(1-\lambda), p_M)$ for $t \in (\tau^*, \tau]$. The average profits of an innovating home firm during the production period can then be expressed as

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[2]The import of drugs into the US from Canada provides an example of the kind of arbitrage we have in mind. Some Canadian pharmacies have been actively soliciting business in the US, where drug prices are substantially higher. Although resources are devoted to discouraging this trade, some consumers continue to buy drugs in Canada and some state governments are attempting to purchase Canadian drugs for their health care programs.

[3]These condition will hold if $u^*(d^*) = \psi u(d^*/\psi)$.

$$\Pi = \theta^* \pi(p_M) + (\theta - \theta^*)\pi(p(\lambda)) \tag{2}$$

where $\theta \equiv \dfrac{1 - e^{-r\tau}}{1 - e^{-rT}}$ and $\theta^* \equiv \dfrac{1 - e^{-r\tau^*}}{1 - e^{-rT}}$ is the share of the production period in which the product is

covered by the home and foreign patents respectively. During the innovation period, home firms invest resources to develop new brands of the differentiated product. Let C(N) represent the cost of R&D required to generate a measure N of new products in the home country measured in terms of the homogeneous good, where C is strictly concave in N. Increasing marginal costs of producing innovations can arise from the existence of a sector-specific human capital input used in the R&D sector along with mobile labor. Firms will invest in R&D up to the point where the cost of an introducing an additional product equals the expected return from the product over the life of the patent,

$$C'(N) = \beta\Pi(\theta, \theta^*, \lambda) \tag{3}$$

where β is the present value of \$1 for the length of the production period. Letting T_I be the time required to produce an innovation, $\beta = e^{-rT_I}(1 - e^{-rT})/r$.

Given policy choice by the governments, conditions (2) and (3) express the pricing decisions of the firms and the equilibrium number of brands that are introduced in the first period. The equilibrium of this two period model is very similar to the steady state of the Grossman and Lai (2002) model, which is an infinite horizon model in which the useful life of new products is exogenously given and corresponds to the production period here. In their model production and innovation take place at each point in time, with the number of newly innovated products entering the market at a point in time equal to the number of products that have reached the end of their useful life. The steady state thus exhibits a constant number of products. The innovation period and production period in our model are thus analogous to the life cycle of a representative product along the steady state path of the Grossman-Lai model.

The equilibrium condition for innovation can be used to derive the effect of policy changes on

innovations. Differentiating (3) and letting a "^" over a variable denote a rate of change we have

$$\hat{N} = \frac{\left[\left(\pi(p_M)(1 + \psi) - \pi(p(\lambda))\right)d\theta^* + \pi(p(\lambda))d\theta - (\theta - \theta^*)\pi'(p(\lambda))p(\lambda)d\lambda/\lambda\right]\gamma}{\Pi} \quad (4)$$

where $\gamma = C'(N)/(NC''(N))$ is the elasticity of innovation with respect to an increase in the profit from innovation. An increase in the length of patents in either country will increase the profits returned from an innovation, and thus raise the amount of innovation that takes place. There will be two factors that determine which country's patent life has the greater impact on the amount of innovation that takes place. One element is the size of the market: foreign patent life will have a relatively bigger impact when home market profits are a relatively larger share of total profits. A second element is the important of arbitrage after the expiration of the home patent. When arbitrage has a significant impact on home country prices following the expiration of the foreign patent (i.e. $\pi(p(\lambda)) \rightarrow 0$), the foreign patent life becomes relatively more important in determining the rate of innovation. If the arbitrage condition is binding, the innovator will be forced to reduce price to meet potential competition from illegal imports once the patent expires in the foreign market. An increase in the level of enforcement will thus raise the profits and encourage innovation for $p(\lambda) \in [c, p_M)$.

Welfare for the home country will be the sum of consumer surplus and net profits of home innovators from innovation and the cost of resources devoted to preventing arbitrage, $F(\lambda)$,

$$W = \beta\left(S(\theta, \theta^*, \lambda)N + \Pi(\theta, \theta^*, \lambda)N\right) - C(N) - F(\lambda)$$

$$(5)$$

$$\text{where} \quad S(\theta, \theta^*, \lambda) \equiv \theta^* s(p_M) + (\theta - \theta^*)s(p(\lambda)) + (1 - \theta)s(c)$$

$S(\theta, \theta^*, \lambda)$ is the average consumer surplus generated over the life of the product in the home country, which will be decreasing in the patent life in each country and in the level of enforcement against arbitrage. Totally differentiating (5) yields

$$\frac{dW}{\beta} = -\Delta(p)Nd\theta - \left[\Delta(p_M) - \Delta(p(\lambda)) + \psi\pi(p_M)\right]Nd\theta^*$$

(6)

$$-\left[(\theta - \theta^*)\,\Delta'(p(\lambda))\,Np'(\lambda) + \frac{F'(\lambda)}{\beta}\right]d\lambda + S(\theta,\theta^*,\lambda)\,dN$$

where $\Delta(p) \equiv s(p) + \pi(p) - s(c)$ is the deadweight loss associated with differentiated products sold at price p. An increase in home patent life, given N, will reduce home welfare because it raises the average deadweight loss over the life of the product. The second term in (6) captures the two conflicting effects of an increase in foreign patent life at fixed N. One effect is to increase the profit received by home country firms in the foreign market, which raises welfare. The second effect is to raise the deadweight loss in the home market when $p(\lambda) < p_M$, because the extension of the foreign monopoly raises the monopoly distortion. The third term in (6) shows that an increase in enforcement against arbitrage by the home country reduces static welfare by raising the deadweight loss during the period when patents are in force at home but not in the foreign country. The final term shows that an increase in the number of home or foreign innovations provide a dynamic gain due to the resulting from the consumer surplus associated with the new products.

The optimal patent policy for the home country involves trading off the static losses from the extension of monopoly against the dynamic gains due to an increased variety of products. Using (3), the optimal choice of home patent life will satisfy

$$\Delta(p(\lambda)) = \frac{\gamma\pi(p(\lambda))\,S(\theta,\theta^*,\lambda)}{\Pi(\theta,\theta^*,\lambda)}$$

(7)

Condition (7) indicates that the optimal patent life occurs where the deadweight loss from an extension of patent life equals the surplus gained from the additional that are generated. Note that the responsiveness

of innovations to the length of the home patent depends on the elasticity of innovations with respect to an increase in profit, γ, and the share of global profits that are obtained in the home market, π/Π. This suggests that the optimal home patent life will be longer the greater the home country share in world profits.

The condition for the optimal level of border enforcement, λ, is

$$(\theta - \theta^*)\, \Delta'(p(\lambda))\, p'(\lambda) + \frac{F'(\lambda)}{N\beta} = \frac{(\theta - \theta^*)\, \pi'(p(\lambda))\, p'(\lambda)\, \gamma\, S(\theta,\theta^*,\lambda)}{\Pi} \qquad (8)$$

The optimal enforcement policy equates the marginal cost of increased enforcement, which is the resource cost plus the increased deadweight loss (when $\boldsymbol{\theta > \theta^*}$), to the marginal benefit. The marginal benefit of increased enforcement is the increase in innovations resulting from the increased profits in the home market. Note that since $\boldsymbol{\pi'(p_M) = 0}$, the marginal benefit of enforcement goes to 0 as $p(\lambda) \rightarrow p_M$ and it will not be optimal to completely eliminate the potential for arbitrage even if enforcement is costless. As $p(\lambda) \rightarrow c$, we have $\Delta'(p) \rightarrow 0$ and $\pi'(p) < 0$. If enforcement is costless, it will be worthwhile to engage in some enforcement activity

Foreign welfare can be expressed as

$$W^* = \beta\, \psi\, S^*(\theta^*)\, N \qquad \text{where} \quad S^*(\theta^*) \equiv \theta^* s(p_M) + (1 - \theta^*)s(c) \qquad (9)$$

Since the foreign country does not engage in innovation and the arbitrage activity generates zero profits, foreign country welfare is determined solely by the consumer surplus from differentiated products. Total differentiation of (9) yields

$$\frac{dW^*}{\beta} = \psi\left(-\left[\Delta(p_M) + \pi(p_M)\right] N d\theta^* + S^*(\theta^*)\, dN \right) \qquad (10)$$

The static cost of extending patent life in the foreign market includes both the deadweight loss and the level of monopoly profits, because the profits from innovation are accruing to home country firms. The necessary condition for choice of patent life by the home country will be

$$\Delta(p_M) + \pi(p_M) = \frac{\gamma\left(\pi(p_M)(1+\psi) - \pi(p(\lambda))\right)S^*(\theta^*)}{\Pi(\theta,\theta^*,\lambda)} \qquad (11)$$

Equation (11) illustrates a trade-off for each country between dynamic welfare gains and static efficiency losses similar to that in for the home country, (7). Note that since S^* is decreasing in θ^* and Π is increasing in θ^*, there can be at most one value of θ^* at which (11) holds for given home policy parameters if γ is a constant. Furthermore, the optimal foreign patent life will be decreasing in the home patent life.

A. The Non-Cooperative Equilibrium

The best responses of the home and foreign countries in (7), (8), and (11) can be used to characterize the Nash equilibrium when countries are setting policies unilaterally. As a benchmark, we begin with the case in which there are no arbitrage possibilities between markets so that innovators can always charge the monopoly price while their patent is in effect in a market.[4] Combining (7) and (11), we must have $S(p_M)\theta + S(c)(1-\theta) = \left(S(p_M)\theta^* + S(c)(1-\theta^*)\right)\psi\Delta(p_M)/\left(\Delta(p_M) + \pi(p_M)\right)$ if there is an interior solution for patent life for both countries. Since the average consumer surplus is decreasing in patent life, a sufficient condition for $\tau > \tau^*$ is $\psi \leq 1$. There are two factors that lead to a lower patent life in the home country when $\psi \leq 1$. The first is that the foreign country has a lower incentive to protect intellectual property since profits go to the home country. The second is that the marginal benefit of extending patent life is greater when the scale of the market is larger at home. If $\psi > 1$, the scale effect and profit

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[4]For example, there may be significant transport costs between countries that prevent arbitrage.

motivations for extending patent life conflict and it is possible that $\tau < \tau^*$ in the Nash equilibrium. It will be assumed in what follows that $\psi \leq 1$.

We now turn to the consideration of the case where arbitrage is possible. For the foreign country, the existence of arbitrage does not affect the static deadweight loss or the surplus gained from a new innovation over its life, $S^*(\theta^*)$, because the local price remains at the competitive level for $t \in (\tau^*, \tau]$ when arbitrage is taking place. However, the existence of arbitrage will mean that an increase in foreign patent life will have a larger impact on home country innovation. Referring to (11), it can be seen that $[\pi(p_M)(1+\psi) - \pi(p(\lambda))]/\Pi$ will be decreasing in $p(\lambda)$. This occurs because an increase in arbitrage (i.e. a reduction in $p(\lambda)$) will reduce the average profits from innovation and will increase the gain experienced by the firm when foreign patent life is extended. The latter effect occurs because an extension of foreign patent life increases profits in the foreign market and reduces the amount of arbitrage that is being undertaken. As a result, the existence of arbitrage will raise the right hand side of (11) relative. Since the right hand side is decreasing in θ^*, the existence of arbitrage will cause the foreign country to choose a longer patent life for given θ.

The impact of arbitrage on the home choice of patent life is more complex, because arbitrage affects the static deadweight loss as well as the responsiveness of innovation to home patent life. Arbitrage reduces the deadweight loss due to patent protection in the home country, which makes the extension of patent life less costly. However, arbitrage also reduces the profits earned by home firms from innovations. This reduces the benefit of patent extension at home, since profits from the home market are a smaller fraction of global profits.

B. Efficient International Agreements

The Nash equilibrium outcome can be compared with the efficient agreement that would be

chosen if the policies were chosen to maximize the sum of home and foreign welfare. Such an outcome would arise if the home and foreign countries were able to commit to an agreement on patent lives, with lump sum transfers being made between countries to achieve the desired distribution of income between countries. Letting world welfare be $W^W = W + W^*$, we can combine (6) and (10) to obtain

$$\frac{dW^W}{\beta} = -\Delta(p(\lambda))Nd\theta - \left[(1+\psi)\Delta(p_M) - \Delta(p(\lambda))\right]Nd\theta^*$$

$$-\left[(\theta - \theta^*)\,\Delta'(p(\lambda))\,Np'(\lambda) + \frac{F'(\lambda)}{\beta}\right]d\lambda + \left[S(\theta,\theta^*,\lambda) + \psi S^*(\theta^*)\right]dN$$

(12)

Equation (12) can be used to illustrate the inefficiencies that arise in the Nash equilibrium. One is due to a dynamic spillover due to the public good nature of intellectual property, since introduction of a new good creates surplus of $S + \psi S^*$ for consumers worldwide. Individual countries will consider only surplus accruing to domestic consumers in setting the optimal policy, which will tend to result in too low a level of patent protection. A second concerns the spillovers between countries that result from changes in patent life. There are two static spillovers from changes in θ^* that are not considered by the foreign country in setting of its patent life. One is the profits to the home country inventors from the extension of patent life. A second is the negative impact of extension of the foreign patent life to the home country consumers, since it increases the deadweight loss in the home country by reducing the amount of arbitrage trade that takes place. Thus, the static cost of raising θ^* could be either greater or less than the value that is considered by the foreign country.

Equation (12) can be used to address the question of whether it will be efficient to choose a uniform life for protection of intellectual property across the two countries. First note that arguments similar to those for the discussion of home country enforcement policy in (8) can be used to show that it will be optimal to choose $p(\lambda) < p_M$ when $\theta > \theta^*$ and arbitrage is profitable. Now consider the effect of an adjustment in the patent lives of the two countries that maintains the total number of innovations,

assuming that we start from an initial position with $\theta \geq \theta^*$. This requires holding the world profits of innovators constant, which by (4) will hold $d\theta^* = -\pi(p(\lambda))/\left[(1 + \psi)\pi(p_M) - \pi(p(\lambda))\right]d\theta$. Substituting this result into (12) yields

$$\frac{dW^W}{\beta} = \left[\frac{\Delta(p_M)(1 + \psi) - \Delta(p(\lambda))}{\pi(p_M)(1 + \psi) - \pi(p(\lambda))} - \frac{\Delta(p(\lambda))}{\pi(p(\lambda))}\right]Nd\theta \qquad (13)$$

A movement toward uniformity of patent lives will raise welfare if the bracketed expression in (13) is negative, which is equivalent to requiring that $\Delta(p_M)/\pi(p_M) < \Delta(p(\lambda))/\pi(p(\lambda))$. In order for a movement toward uniformity of patent lives to raise welfare, the deadweight loss per dollar of profit earned in the foreign market must be less than that in the home country at the initial values.

In the case where there are exogenous barriers that prevent arbitrage between markets, $p(\lambda) = p_M$ and a movement toward uniformity will have no effect on world welfare. In this case the distortions in the two markets are equal, so that any adjustment in patent lives that maintains the aggregate profits of innovators (i.e. $d\theta^* = d\theta/\psi$) leaves the aggregate deadweight loss required a given level of innovation constant. If arbitrage is possible, the above results indicate that enforcement will be incomplete so that $p(\lambda) < p_M$. If the demand curves are linear, then it can be shown that $\Delta(p)/\pi(p)$ is increasing in p and

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