The North's Intellectual Property Rights Standard for the South?*

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Abstract

We build a multi-sectoral North-South trade model to analyze international intellectual property rights (IPR) protection. By comparing the Nash equilibrium IPR protection standard of the South (the developing countries) with that of the North (the developed countries), we find that the former is naturally weaker than the latter. Moreover, we show that both regions can gain from an agreement that requires the South to harmonize its IPR standards with those of the North, and the North to liberalize its traditional goods market. This demonstrates the merits of multi-sectoral negotiations in the GATT/WTO.

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1 Introduction

One important breakthrough of the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) is the signing of the Agreement on Trade-Related Aspects of Intellectual Property Rights (the TRIPS Agreement), which stipulates that all members adopt a set of universal minimum standards on intellectual property rights (IPR) protection.[1] According to many observers (e.g., Reichman, 1995), most of the terms of the agreement are based on the prevailing standards in developed countries (the North) at the time of the negotiation. The major consequence is that developing countries (the South) have to strengthen substantially the legal protection of IPR. Based on this observation, it is often argued that the agreement "forces" the South to harmonize its IPR standards with those of the North.

The TRIPS Agreement has raised several questions. For example, has the South been doing too little to protect IPR (from the South's and the global welfare points of view)? What are the welfare consequences, for the South, the North and the world, from strengthening IPR protection in the South? From the global welfare point of view, does the South protect too much if it adopts the North's IPR standard? How can we make the TRIPS Agreement compatible with the South's incentive? Answers to these questions would help us address other important issues as well. For example, if raising the South's IPR standard improves the world's welfare, then the TRIPS can potentially make all regions better off. This paper deals with the above questions and issues.

We build a model with two regions in the world, the North and the South, which trade two types of goods, differentiated products and traditional products. Innovation and imitation are carried out in the differentiated-products sectors of both regions. We assume that the North and the South adopted their respective Nash equilibrium IPR standards before the TRIPS was put in place, and the TRIPS Agreement requires both regions to adopt the pre-TRIPS IPR standard of the North as a minimum standard. The cost-

[1] See UNCTAD (1997) and Maskus (1998, 2000) for more about the TRIPS Agreement and related issues.

benefit analysis we adopt is not fundamentally different from Nordhaus's (1969) classical work in which he calculates the optimal patent length. Like his analysis, our optimal IPR protection strikes an optimal balance between the gains from increased R&D efforts and the deadweight losses resulting from the prolonged monopoly power of the innovators. Based on our analysis, we find that the South's equilibrium IPR standard is naturally not as strong as that of the North. Moreover, it is globally welfare-improving for the South to raise its IPR standard to harmonize with the North's pre-TRIPS level. The major effects of the TRIPS are: the South's consumers lose by paying higher prices, the North's producers gain higher profits, but all consumers gain from a larger variety of goods. On balance, the South's welfare decreases, the North's increases, but the total welfare of the two regions rises, because of the existence of a positive inter-regional externality. The externality arises because an increase in a region's IPR protection raises the profits of firms and enlarges the product variety in another region without raising the deadweight loss in the latter. However, an agreement that requires the South to raise its IPR standard without compensation benefits the North at the expense of the South, and would not be compatible with the South's incentive.

Therefore, we extend the above IPR model to incorporate multi-sectoral bargaining between the North and South to show that multi-sectoral negotiations (or multi-issue negotiations) in GATT/WTO can be mutually beneficial to both regions. For example, it would benefit both regions for the South to harmonize its IPR standard with the North's, in exchange for the North lowering its import tariffs against South's exports of traditional products. In this case, multi-issue negotiations can achieve incentive-compatible and mutually beneficial outcomes while single-issue negotiations cannot, since it is globally welfare-improving for each side to make concessions on a different issue.

There have been many theoretical and empirical studies on the effects of IPR protection on innovation, trade, foreign direct investment and economic growth.[2] As far as we are

[2]See, for example, Mansfield (1986), Maskus and Penubarti (1995), Gould and Gruben (1996), Richardson and Gaisford (1996), Horowitz and Lai (1996), Lai (1998) and Glass and Saggi (2001). For example, Lai (1998) finds that, since stronger IPR protection in the South can

aware, however, the present paper is among the first to assume that both the North and the South have innovative capabilities and to consider optimal degrees of IPR protection for the North, the South and the world as a whole. It is also among the first to analyze the merits of raising the South's IPR protection in the broader context of multi-sectoral (or multi-issue) negotiations, such as in the GATT or WTO. There are some other studies in the literature that are related to our study in one way or another. Both Chin and Grossman (1990) and Deardorff (1992) examine welfare effects of extending IPR protection from the North to the South. They find, as we do, that many results depend on the size of the South's market.[3] However, there are two notable differences between these papers and our study. First, they assume that the South does not have innovative capability. Second, they examine only the case in which the South has either full or no IPR protection. Diwan and Rodrik (1991) also consider various degrees of IPR protection in the North and the South. Interestingly, they find that to maximize the global welfare, which is the equally weighted sum of the North's and the South's welfare, the rates of patent protection in the two regions must be identical. They emphasize the taste difference between the two regions and assume no innovative capability in the South. Helpman (1993) uses a dynamic general equilibrium North-South model to study IPR protection, growth and welfare. He assumes that the North specializes in innovation and the South specializes in imitation. He finds that tightening IPR protection in the South hurts the South and may or may not benefit the North. We believe that this result needs to be modified if we take into account the South's innovative capability. We examine this issue in our partial equilibrium model, which is able to include a more detailed microeconomic analysis of firm and government behaviors.[4] Unlike our work, none of the above-mentioned papers

increase the rate of innovation, there is a tradeoff between the dynamic gains and static losses from strengthening IPR protection in the South.

[3] In particular, Deardorff (1992) shows that global welfare will be reduced if the North's IPR standard is extended to a very large part of the South. In a related study, Yang (1998) argues that because of the free-rider problem existing among the Southern countries, the South's IPR protection is too weak.

[4] Taylor (1993) has an interesting study on how firms in the North respond to lax IPR protection in the South by creating market-made protection, i.e., technology masquing.

deals with the incentive-compatibility issue of the South's concessions in IPR. Our result that multi-issue negotiation makes both the South and North better off echoes the recent literature on linkage issue related to international trade negotiations (see Horstmann, Markusen and Robles, 2001).

More recently, McCalman (2001) makes estimates of the transfer of income from consumers to producers (mostly a transfer from South to North) resulted from the TRIPS. However, he does not estimate the welfare gains from larger product variety, which can be substantial. As we argue below, such a gain would actually outweigh the deadweight loss so that a rise in the South's IPR protection is globally welfare-improving.[5]

The organization of the paper is as follows. Section 2 lays out the basic features of the model and derives the Nash equilibrium pre-TRIPS IPR standards in the two regions. Section 3 examines the effect of varying the South's IPR protection standard on global welfare. Section 4 introduces a bargaining game between the two regions in a multi-sectoral negotiation. Section 5 summarizes the findings.

2 A Multi-sectoral Model with IPR Protection

There are two regions in the world, the North and the South. The North has higher innovative capability than the South. There are two distinct regimes, the pre-TRIPS regime and the post-TRIPS regime. We assume that in the pre-TRIPS regime, the North and the South adopt their respective Nash equilibrium IPR standards. While the TRIPS Agreement covers extensive issues, it is a widely shared view that establishing a global minimum IPR standard is the key.[6] To capture the view that the TRIPS adopted the prevailing IPR standard of the North at the time of signing the agreement, we assume that

[5] He finds that the net transfers the US receives from the TRIPS to be up to 40% of the gains associated with trade liberalization in the WTO, while the developing countries pay net transfers of up to 64% of the gains they receive from trade liberalization. The large amount of transfers involved shows that the IPR issue can indeed be an important leverage for the South to elicit trade concessions from the North.

[6] See Hoekman and Kostecki (1995) for example.

in the post-TRIPS regime the North's pre-TRIPS IPR standard is set as the minimum standard for both regions. We shall derive the Nash equilibrium IPR standards in the pre-TRIPS regime in this section; in the next section, we evaluate welfare consequence of the TRIPS Agreement.

2.1 Preliminaries

There are two traded sectors in each region: a differentiated goods sector and a traditional good sector. First let us focus on the differentiated products sector. Consider one or many industries with very high potential for product innovation. Assume that any newly developed product will become obsolete after T periods.[7] Although IPR protection refers to a broad range of legal activities, here we use patent protection as representative of IPR protection. Region k's government sets a patent length T_k for $k \in \{s, n\}$, where s denotes the South and n denotes the North. We assume "national treatment", i.e. governments provide the same protection to all firms, regardless of where they are invented. This had been practiced by many countries even before TRIPS. All imitated products are prohibited from being produced or sold in region k for T_k periods. The time horizon is infinite. At the beginning of period 0, both governments announce and immediately enforce patent length of T_s and T_n respectively for all goods invented in or after period 0. In each period, potential innovators decide whether or not to make individual R&D investments. If they do, differentiated products will be developed. We assume that innovators (i.e. firms) and consumers face exactly the same environment in every period. (We can imagine there is a pool of resources that can perform product development and production every period.) Thus, potential innovators will take the same R&D action in every period. In particular, the same *numbers* of differentiated products will be developed in every period. Let M_k be the number of differentiated products developed in region k in each period. We assume that the sets of products developed in the North and South are non-intersecting, and so

[7] T can be regarded as the length of the product cycle. After T periods, the product has no economic value.

a product developed in one region is different from any product developed in the other region. Products invented in different periods are necessarily different to qualify for IPR protection. The same firm could develop many products in many periods. Nonetheless, for ease of exposition, we treat different products (whether in the same period or not) as being invented by different firms.

Before period T, the numbers of differentiated products (invented under the new IPR regime) whose patents have expired as well as not expired change from one period to the next. After period T, these numbers become steady. Therefore, a steady state is attained after period T. To simplify the analysis, we assume that there is no discount of the future. Since there is no discounting, we can focus our attention on the steady-state flow welfare for the purpose of welfare analysis. This can be justified by "overtaking criterion" in dynamic optimization theory.[8] In every steady-state period, there are TM_s South-invented products that are economically viable and TM_n North-invented products that are economically viable, of which $T_s(M_s + M_n)$ products' patents are still in force in the South and $T_n(M_s+M_n)$ products' patents are still in force in the North. Although the number of products is discrete, we treat it as continuous in our mathematical derivation for easier handling.

Following some previous work, we assume a quasi-linear utility function for the representative consumer. With free trade in differentiated products and the traditional product, the steady state flow utility of the representative consumer in region k (where $k \in \{s, n\}$) in period t is:

$$u_k(t) = T_k \left[\sum_{j\in\{n,s\}} \int_0^{M_j} x_{jk}(i)^\alpha \mathrm{d}i \right] + (T - T_k) \left[\sum_{j\in\{n,s\}} \int_0^{M_j} \widetilde{x_{jk}}(i)^\alpha \mathrm{d}i \right] + (az_k - \frac{1}{2} e_k z_k^2) + y_k,$$

[8]See, for example, Burmeister (1980), pp. 249-250. Basically, with no discounting, a path $\{\hat{c}, \hat{k}, \dot{\hat{k}}\}$ overtakes the path $\{c, k, \dot{k}\}$ if $\lim_{T\to\infty} \int_0^T [u(\hat{c}) - u(c)]dt \geq 0$, where c is the control variable, k is the state variable, and $u(c)$ is the instantaneous welfare corresponding to the path $\{c, k, \dot{k}\}$. A feasible path $\{\hat{c}, \hat{k}, \dot{\hat{k}}\}$ is optimal if it overtakes all other feasible paths. It can be easily seen that if the steady state value of $u(\hat{c})$ is higher than that of any other feasible values $u(c)$, then $\{\hat{c}, \hat{k}, \dot{\hat{k}}\}$ overtakes all other paths, and is therefore optimal.

where $0 < \alpha < 1$ and $\frac{2a}{e_k} \geq z_k \geq 0$.[9] Parameters a and e_k are positive constants; $x_{jk}(i)$ ($\widetilde{x_{jk}}(i)$, respectively) is the consumption of differentiated product i developed in region j and consumed in region k, whose patent has not expired (has expired, respectively); z_k is the consumption of a traditional product z (e.g., textile products) in region k. Finally, y_k is a competitively produced non-traded composite good, produced and consumed only in region k. The price of y_s is normalized to one.[10] Note that if $e_s \neq e_n$, then consumers in different regions will demand the differentiated and the traditional products in different ratios, even if prices are equal across regions. In particular, if $e_s < e_n$, a consumer in the South demands a higher ratio of traditional product to differentiated products than a consumer in the North does. In each period, each consumer in region k maximizes her utility subject to a budget constraint, $I_k \geq T_k \left[\sum_{j\in\{n,s\}} \int_0^{M_j} p_{jk}(i)x_{jk}(i)\mathrm{d}i\right] + (T - T_k)\left[\sum_{j\in\{n,s\}} \int_0^{M_j} \widetilde{p_{jk}}(i)\widetilde{x_{jk}}(i)\mathrm{d}i\right] + p_k(z)z_k + y_k$, where $p_{jk}(i)$ ($\widetilde{p_{jk}}(i)$, respectively) is the price of product i developed in region j and sold in region k whose patent has not expired (has expired, respectively); $p_k(z)$ is the price of product z sold in region k, and expenditure I_k is exogenously given. To simplify the notation, define $\epsilon \equiv 1/(1-\alpha)$ and $A \equiv (1-\alpha)\alpha^{(1+\alpha)\epsilon}$.

The instantaneous demand for products x (the differentiated products) whose patents have not expired, that for those whose patents have already expired, and that for product z (the traditional product) by the representative consumers are, respectively,

$$x_{jk}(i) = \left[\frac{p_{jk}(i)}{\alpha}\right]^{-\epsilon}, \quad \widetilde{x_{jk}}(i) = \left[\frac{\widetilde{p_{jk}}(i)}{\alpha}\right]^{-\epsilon} \quad \text{and} \quad z_k = \frac{a - p_k(z)}{e_k}.$$

When $a < p_k(z)$, $z_k = 0$. We shall maintain the assumption that a is sufficiently large to ensure interior solutions. Let N_k be a shift parameter on aggregate demand, which can be interpreted as the number of consumers in region k. (We shall assume that $N_n > N_s$. Note that this should not be literally interpreted as the North's population being higher, but rather that the size of the market for differentiated products is larger in the North, as

[9]For $\frac{2a}{e_k} < z_k$, the utility derived from good z is zero. We shall maintain the assumption that a is sufficiently large to avoid corner solutions.

[10]We assume that there is free trade in order to focus on IPR policy. Qiu and Lai (2001), on the other hand, compare South's and North's tariffs but treat IPR policy as given.

will become clear next.) Thus, the corresponding aggregate demands are, respectively:

$$X_{jk}(i) = N_k \left[\frac{p_{jk}(i)}{\alpha}\right]^{-\epsilon}, \quad \widetilde{X_{jk}}(i) = N_k \left[\frac{\widetilde{p_{jk}}(i)}{\alpha}\right]^{-\epsilon} \quad \text{and} \quad Z_k = N_k \left[\frac{a - p_k(z)}{e_k}\right].$$

Define $e_n \equiv e$ and $\eta_k \equiv eN_k/e_k$. Then, we can rewrite

$$Z_k = \eta_k \left[\frac{a - p_k(z)}{e}\right].$$

Therefore, N_s/N_n is the size of the market for differentiated products in the South relative to that of the North, and η_s/η_n is the size of South's market for the traditional product relative to that of the North. Note that $\eta_n = N_n$ and $\eta_s = eN_s/e_s$. Assuming that $e_s < e_n$, so that the South's propensity to consume the traditional product relative to the differentiated products is higher, we have $\eta_s/\eta_n > N_s/N_n$. It is indeed plausible that $\eta_s/\eta_n > 1$ and $N_s/N_n < 1$. We shall discuss more about this in section 4.

For simplicity, assume that the unit cost of production for all x products is constant and equal to one unit of good y in that region regardless of the location of production.[11] Hence, the per-period operating profit (i.e., profit not including innovation costs) of firm i based in region j selling in region k is $\pi_{jk}(i) = [p_{jk}(i) - 1]X_{jk}(i)$. Under IPR protection, firm i has a monopoly on product i. As a result, for products whose patents have not expired,

$$p_{jk}(i) = \frac{1}{\alpha}, \quad X_{jk}(i) = N_k\alpha^{2\epsilon}, \quad \text{and} \quad \pi_{jk}(i) = N_k A.$$

We assume imitation costs are zero. Therefore, for products whose patents have expired, prices are driven down to the unit cost of production because of imitation. Thus

$$\widetilde{p_{jk}}(i) = 1, \quad \widetilde{X_{jk}}(i) = N_k\alpha^{\epsilon}, \quad \text{and} \quad \widetilde{\pi_{jk}}(i) = 0.$$

To avoid unnecessary complexity, we omit the details of the production of traditional good z by using an endowment model. Moreover, we assume that the South is relatively more abundantly endowed with good z than the North in the sense that in every period, t,

[11] In general, labor costs are lower in the South than in the North while innovation costs are higher in the South than in the North. But, our emphasis here is on the North-South difference in innovation costs.

region k is endowed with $\eta_k \bar{z}_k$ units of the traditional good and that $\bar{z}_n < \bar{z}_s$. Therefore, in autarky, the price of good z would be lower in the South than in the North, and when there is free trade the South would export this good to the North. Let $\eta_s z_{ss}$ and $\eta_s z_{sn}$ be the quantities of the South-produced traditional good sold in South's market and exported to North's market, respectively, with $z_{ss} + z_{sn} = \bar{z}_s$. Let τ be the tariff imposed on each unit of good z imported to the North. Assume that the demand intercept a is sufficiently large and that $\bar{z}_s - \bar{z}_n > \tau/e$. Then, we have the following equilibrium conditions for the traditional good sector in both markets:

$$p_n(z) = a - e(\bar{z}_n + \delta z_{sn}), \quad p_s(z) = a - e z_{ss} \quad \text{and} \quad p_n(z) = p_s(z) + \tau, \quad \text{where} \quad \delta \equiv \eta_s/\eta_n.$$

Solving the above equilibrium conditions gives

$$z_{sn} = \frac{e(\bar{z}_s - \bar{z}_n) - \tau}{e(1+\delta)} \quad \text{and} \quad p_n(z) = \frac{a(1+\delta) - e(\bar{z}_n + \delta \bar{z}_s) + \delta\tau}{e(1+\delta)}. \tag{1}$$

The total revenue per period from sector z is therefore $R_{zn} = \eta_n[p_n(z)\bar{z}_n + \tau z_{sn}]$ for the North and $R_{zs} = \eta_s p_s(z)\bar{z}_s$ for the South. Consumer surplus per period derived from this sector in the North and South are respectively $\frac{\eta_n}{2e}[a - p_n(z)]^2$ and $\frac{\eta_s}{2e}[a - p_s(z)]^2$. Note that the per-period quantities in the traditional-good sector are also the steady-state quantities.

The total steady state flow welfare in region k is

$$W_k = U_k + U_{zk},$$

where U_k is region k's steady state flow welfare derived from all sectors excluding sector z, whereas U_{zk} is the steady state flow welfare in region k derived exclusively from sector z. We shall focus on the analysis of IPR protection in the rest of this section and in Section 3. Since IPR protection affects sector x only, and will not affect U_{zk}, we shall ignore sector z until Section 4.

2.2 Analysis of the Pre-TRIPS Regime

Based on the analysis in the preceding section, region k's (where $k \in \{s, n\}$) representative consumer's steady state flow utility at time t is

$$u_k(t) = T_k(M_s + M_n)(1-\alpha)\alpha^{2\alpha\epsilon} + (T - T_k)(M_s + M_n)(1-\alpha)\alpha^{\alpha\epsilon} + [a - p_k(z)]^2/(2e_k) + I_k.$$

The first term on the right hand side refers to goods whose patents have not expired, and the second term refers to goods whose patents have expired.

We now turn to the firms' profits. Assume that in each period the innovation costs of different products are different. Some goods are easier to develop and some goods are harder to develop. We index goods in ascending order based on the innovation costs, i.e., a good with a lower index i has a lower innovation cost than a good with a higher i. It is assumed that the innovation cost of product i based in region k is $a_k \cdot i^{1/b_k}$ where $a_k > 0$ and $0 < b_k < 1$ are parameters.[12]

All firms sell their products in both the South's and North's markets. Thus, the life-time profit of firm i based in region k (over the entire life of product i) is

$$\Pi_k(i) = \int_0^{T_s} \pi_{ks}(i)\mathrm{d}t + \int_0^{T_n} \pi_{kn}(i)\mathrm{d}t - a_k \cdot i^{1/b_k} = (N_s T_s + N_n T_n)A - a_k \cdot i^{1/b_k}.$$

In each period, the marginal firm in the North, M_n, and that in the South, M_s, are defined as firms that earn zero profit, i.e., $\Pi_n(M_n) = 0$ and $\Pi_s(M_s) = 0$, respectively. This leads to

$$M_n = \left(\frac{\mu}{a_n}\right)^{b_n} \quad \text{and} \quad M_s = \left(\frac{\mu}{a_s}\right)^{b_s}, \quad \text{where} \ \ \mu \equiv (N_s T_s + N_n T_n)A.$$

Thus, M_s products are developed in the South and M_n products are developed in the North in each period. We define the steady state flow profits of a region in a period as the total life-time profits of all firms that innovate in that period. It turns out that these flow profits are equal to $\int_0^{M_k} \Pi_k(i)\mathrm{d}i$.

[12] We could instead use a more general cost function $f(i)$, where $f(0) \geq 0$, $f'(.) > 0$, $f''(.) > 0$. But our results would not be altered qualitatively. Nor would our results be affected qualitatively if the future were discounted.

Before we proceed further, we now make two assumptions about the asymmetry between the two regions. First, we assume that $N_n > N_s$. Although we can consider the South's population to be higher than the North's, it is widely documented that the North's demands for innovative products, such as computers, pharmaceuticals and biotechnological products, are higher than those of the South. Second, we assume that the North has higher innovative capability such that in equilibrium $M_s < M_n$. There are many combinations of a_s, a_n, b_s and b_n that can lead to this very plausible equilibrium outcome. For example, $b_s = b_n$ & $a_s > a_n$, or $b_s < b_n$ & $a_s = a_n$, are sufficient conditions for $M_s < M_n$. It would be seen later that these two assumptions would lead to the result that the North protects IPR stronger than the South does.

The steady state flow welfare of region k is given by

$$W_k(T_s, T_n, M_s, M_n) = N_k u_k(t) + \int_0^{M_k} \Pi_k(i)\mathrm{d}i + R_{zk}$$

$$= N_k T_k[(M_s + M_n)(1-\alpha)\alpha^{2\alpha\epsilon}] + N_k(T - T_k)[(M_s + M_n)(1-\alpha)\alpha^{\alpha\epsilon}] + N_k I_k$$

$$+ M_k(N_s T_s + N_n T_n)A - \frac{b_k}{1+b_k} M_k^{(1+b_k)/b_k} + U_{zk}.$$

Each region chooses its IPR protection policy T_k strategically to maximize its welfare. To characterize the Nash equilibrium, we first obtain the policy reaction functions of the North and of the South. Since the reaction functions of the North and the South are symmetric up to the values of the parameters, let us focus on the South for the time being. Assuming an interior solution, the optimal response T_s for any given T_n is obtained from the following equation:

$$\frac{\mathrm{d}W_s}{\mathrm{d}T_s} = \frac{\partial W_s}{\partial T_s} + \frac{\partial W_s}{\partial M_s}\frac{\partial M_s}{\partial T_s} + \frac{\partial W_s}{\partial M_n}\frac{\partial M_n}{\partial T_s} = 0. \tag{2}$$

Note that

$$\frac{\partial W_s}{\partial T_s} = -N_s\{M_s[1 - (1+\alpha)\alpha^{\alpha\epsilon}] + M_n(1 - \alpha^{\alpha\epsilon})\}(1-\alpha)\alpha^{\alpha\epsilon} < 0.$$

That is, the marginal effect of lengthening IPR protection, given that the number of products remains unchanged, is negative. It is the sum of consumer losses and producer gains, which add up to a deadweight loss. We denote this social marginal cost of IPR protection in the South as $MC_s \equiv |\partial W_s/\partial T_s|$, which increases with T_s.

On the other hand, lengthening IPR protection in the South encourages more innovations in both the North and the South, which enlarges product variety and so raises consumer welfare. Thus,

$$\frac{\partial W_s}{\partial M_s}\frac{\partial M_s}{\partial T_s} = N_s[T - T_s(1-\alpha^{\alpha\epsilon})](1-\alpha)\alpha^{\alpha\epsilon}\frac{\partial M_s}{\partial T_s} > 0,$$

$$\frac{\partial W_s}{\partial M_n}\frac{\partial M_n}{\partial T_s} = N_s[T - T_s(1-\alpha^{\alpha\epsilon})](1-\alpha)\alpha^{\alpha\epsilon}\frac{\partial M_n}{\partial T_s} > 0,$$

the sum of which captures the social marginal benefit (MB_s) from extending T_s. Since

$$\frac{\partial M_s}{\partial T_s} = \frac{N_s A}{\mu} b_s M_s \quad \text{and} \quad \frac{\partial M_n}{\partial T_s} = \frac{N_s A}{\mu} b_n M_n,$$

the marginal benefit MB_s decreases in T_s.

The South's reaction function is therefore obtained from equating MC_s to MB_s, which is reduced to[13]

$$M_s[1-(1+\alpha)\alpha^{\alpha\epsilon}] + M_n(1-\alpha^{\alpha\epsilon}) = \frac{N_s A}{\mu}[T - T_s(1-\alpha^{\alpha\epsilon})](b_s M_s + b_n M_n). \tag{3}$$

Invoking symmetry, we obtain the reaction function of the North

$$M_n[1-(1+\alpha)\alpha^{\alpha\epsilon}] + M_s(1-\alpha^{\alpha\epsilon}) = \frac{N_n A}{\mu}[T - T_n(1-\alpha^{\alpha\epsilon})](b_n M_n + b_s M_s). \tag{4}$$

Equations (3) and (4) jointly determine the Nash equilibrium, denoted by T_s^* and T_n^*. Refer to Figure 1.

[Figure 1 about here]

Note that both the South's reaction function and the North's reaction function are downward sloping in the (T_s, T_n) space. For example, the right hand side of equation (3)

[13]The second-order condition for the South is automatically satisfied as it can now be easily checked that $\mathrm{d}^2 W_s/\mathrm{d}T_s^2 < 0$.

(hereinafter $RHS(3)$) decreases with both T_s and T_n, while the left hand side of equation (3) (hereinafter $LHS(3)$) increases with both T_s and T_n. Therefore, $(\mathrm{d}/\mathrm{d}T_n)[LHS(3) - RHS(3)] > 0$ and $(\mathrm{d}/\mathrm{d}T_n)[LHS(3) - RHS(3)] > 0$. By the Implicit Function Theorem, T_s decreases as T_n increases, as we move along the South's reaction curve in the (T_s, T_n) space. The same is true for the North's reaction function. Thus, stronger protection in the North makes it optimal for the South to protect less. The main reason for the substitution effect of the North's protection for the South's protection (as far as the South is concerned) is that as T_n increases, product variety is enlarged due to the greater incentive for firms to innovate, and so the $MC_s(T_s)$ curve, which plots MC_s on a diagram with T_s on the horizontal axis, shifts up. This calls for a reduction of IPR protection in the South. On the other hand, the $MB_s(T_s)$ curve, which plots MB_s on the same diagram, shifts down when consumers obtain increased product variety, due to the decreasing effect of variety on the marginal benefit. This also calls for a reduction of IPR protection in the South.

It can also be shown that the South's reaction curve is steeper than the North's reaction curve in the (T_s, T_n) space. Hence, the Nash equilibrium is stable (see Appendix A).

To compare the values of T_s^* and T_n^*, we first observe that because $M_n > M_s$, $LHS(3) > LHS(4)$ for all T_s and T_n. Suppose we set $T_s = T_n = \xi$ in both (3) and (4). Then, $RHS(3) < RHS(4)$ since $N_s < N_n$. Moreover, the RHS of both equations decreases with ξ, and the LHS of both equations increases with ξ. Hence, the value of ξ obtained from (3) is less than that obtained from (4). This, together with the fact that the South's reaction function is steeper than the North's reaction function, implies that the two curves must intersect at a point above the 45° line, which means that $T_s^* < T_n^*$ (see Figure 1).

The above analysis also indicates two reasons for $T_s^* < T_n^*$. First, the North has more innovations than the South ($M_s < M_n$), because the North has sufficiently higher innovative capability. Second, the North's market size is larger than the South's ($N_s < N_n$).

Next, we check the constraints on the parameters to ensure an interior solution of T_s^*.

Note that a necessary and sufficient condition for $T_s^* > 0$ is that the value of T_n (given that $T_s = 0$) on the South's reaction function is greater than the value of T_n (given that $T_s = 0$) on the North's reaction function. A necessary condition for this inequality to hold is $N_n A[T - T_n(1 - \alpha^{\alpha\epsilon})] < N_s AT$, which, together with the condition $T \geq T_n$, implies $N_s/N_n > \alpha^{\alpha\epsilon}$. Therefore, the market in the South has to be sufficiently large compared with the market in the North in order for the South to have any incentive to protect IPR.

Finally, we examine the implications of market size for equilibrium IPR standards. We find that *the equilibrium IPR protection in the South (North) is stronger when the market in the South (North) becomes larger, or the market in the North (South) becomes smaller.* Mathematically,

$$\frac{\partial T_s^*}{\partial N_s} > 0, \frac{\partial T_s^*}{\partial N_n} < 0, \quad \frac{\partial T_n^*}{\partial N_n} > 0, \text{ and } \quad \frac{\partial T_n^*}{\partial N_s} < 0. \tag{5}$$

The proof is given in an appendix available from the authors upon request.

It is interesting to understand why the two market sizes have opposite impacts on the optimal IPR protection. The effects of N_n on the South's reaction function is that a larger market in the North results in greater product variety, which increases the marginal cost, MC_s, of the IPR protection in the South and lowers the marginal benefit, MB_s, of the IPR protection in the South, for any given T_n. Therefore, an increase in N_n shifts the South's reaction function inward. The effects of N_s on the South's reaction function is more complicated. On the one hand, a larger market in the South also leads to greater product variety, which should lessen the IPR protection in the South. On the other hand, there are more consumers in the South who benefit from increasing the IPR protection in the South, and, as a result, the marginal benefits, MB_s, of the IPR protection in the South increase. We find that this latter effect dominates the former one and thus an increase in N_s shifts the South's reaction function outward. By the same argument, an increase in N_n shifts the North's reaction function out, while an increase in N_s shifts the North's reaction function in. Consequently, we obtain the results given in (5).

We now conclude this section. Just like Chin and Grossman (1990), we also find that it is optimal for the South to protect IPR when its market is sufficiently large. Moreover, we find that as the market in the South grows, it is individually optimal for the South to strengthen its IPR protection. However, the South's incentive to protect IPR can never be as strong as the North's incentive so long as the North has a larger market for differentiated products and has more innovations than the South does.

3 The Post-TRIPS Regime and Global Welfare

In the post-TRIPS regime, both regions are required to adopt the North's pre-TRIPS IPR protection, T_n^*, as the minimum standard. We shall evaluate the welfare consequence of such a measure. But let us first identify the equilibrium in the post-TRIPS regime, i.e. the equilibrium subject to the constraints $T_s \geq T_n^*$ and $T_n \geq T_n^*$. In other words, given that T_n^* is the minimum standard, what standards would the two regions adopt?

When governments adopt new IPR standards, the numbers of products invented in the regions in each period are different from those in the pre-TRIPS regime. Again, we can calculate the equilibrium policies based on the new steady-state welfare levels.[14] Thus, we can adopt a similar analysis as developed in section 2.2. It can be easily shown that the unique post-TRIPS equilibrium is $T_s = T_n^*$ and $T_n = T_n^*$. That is, both regions simply adopt the North's pre-TRIPS IPR protection. The intuition is as follows. From the last section, we see that the North wants to lower T_n as the South increases T_s; conversely, the South wants to lower T_s as the North increases T_n. Therefore, as T_s is forced to increase from T_s^* to T_n^*, the North would want to reduce T_n below T_n^*. Given the constraint $T_n \geq T_n^*$, however, the optimal response for the North is $T_n = T_n^*$. Given that $T_n = T_n^*$, the South's unconstrained best response is $T_s = T_s^*$. However, under the constraint $T_s \geq T_n^*$, the best response of the South is $T_s = T_n^*$.

To evaluate world welfare, let us first define world (or global) welfare simply as the sum of the North's and the South's welfare, i.e., $W = W_s + W_n$. To evaluate whether the minimum IPR standard stipulated by TRIPS is welfare-improving for the world, we first

[14]The new steady state starts T periods after the TRIPS is invoked.

find an expression for the effect of T_s on global welfare. Then, we discuss the properties of the globally optimal IPR standard of the South given that $T_n = T_n^*$. Finally, we evaluate the global welfare effect of increasing T_s from T_s^* to T_n^* given that $T_n = T_n^*$.

Based on the analysis in the last section, the North's steady state flow welfare at $T_n = T_n^*$ is given by

$$W_n(T_s, T_n^*, M_s, M_n) = N_n(M_n + M_s)(1-\alpha)\alpha^{\alpha\epsilon}[T - T_n^*(1-\alpha^{\alpha\epsilon})]$$
$$+N_n I_n + M_n(N_s T_s + N_n T_n^*)A - \frac{b_n}{1+b_n} M_n^{(1+b_n)/b_n} + U_{zn}.$$

Recalling that $M_n = (\mu/a_n)^{b_n}$ where $\mu = (N_s T_s + N_n T_n)A$, we can easily see

$$\frac{\mathrm{d}W_n}{\mathrm{d}T_s} = \frac{\partial W_n}{\partial T_s} + \frac{\partial W_n}{\partial M_n} \cdot \frac{\partial M_n}{\partial T_s} + \frac{\partial W_n}{\partial M_s} \cdot \frac{\partial M_s}{\partial T_s} > 0. \tag{6}$$

A similar inequality can be shown for the South. Therefore, *a region always benefits from stronger IPR protection in the other region, i.e.,* $\mathrm{d}W_n/\mathrm{d}T_s > 0$ *and* $\mathrm{d}W_s/\mathrm{d}T_n > 0$.[15] The benefit comes from enlarging product variety in both regions ($\partial M_k/\partial T_s > 0$ and $\partial M_k/\partial T_n > 0$, for $k = \{s, n, \}$) and increasing innovators' profits ($\partial \Pi_k(i)/\partial T_s > 0$ and $\partial \Pi_k(i)/\partial T_n > 0$, for $k = \{s, n, \}$). Specifically, with a stronger IPR protection in the foreign region, but with its own IPR protection unchanged, a region's consumers enjoy larger product variety with no price hikes (call it *variety spillover*), and its firms also receive more profits (call it *profit spillover*). There is, therefore, a positive inter-regional externality from strengthening IPR protection. Since a region's individually optimal IPR protection does not take into account this positive inter-regional externality, IPR is under-protected from the world's point of view if regions all adopt their individually optimal IPR standards as in the pre-TRIPS regime.

We now turn to consider the impact of increasing the South's IPR protection on global welfare given that $T_n = T_n^*$. Since $W(T_s) = W_n(T_s) + W_s(T_s)$, by (2) and (6), we have,

$$\frac{\mathrm{d}W}{\mathrm{d}T_s}|_{T_s = T_s^*} = \frac{\mathrm{d}W_s}{\mathrm{d}T_s}|_{T_s = T_s^*} + \frac{\mathrm{d}W_n}{\mathrm{d}T_s}|_{T_s = T_s^*} > 0. \tag{7}$$

[15] If, however, consumers from the two regions have different tastes for the products, it is possible that the North (South) cannot always benefit from stronger IPR protection in the South (North), as shown by Diwan and Rodrik (1991).

That is, provided that there is no corner solution for T_s^*, slightly increasing the South's IPR protection from its individually optimal level T_s^* increases global welfare. This is due to the positive externality of IPR protection indicated above. This result supports the argument for increasing the South's IPR protection. The question is how much the South's IPR protection should be increased in order to achieve global welfare optimum.

Differentiating $W(T_s)$ with respect to T_s gives

$$\frac{1}{(1-\alpha)\alpha^{\alpha\epsilon}N_s}\left(\frac{\mathrm{d}W}{\mathrm{d}T_s}\right) = -(M_s + M_n)[1-(1+\alpha)\alpha^{\alpha\epsilon}]$$

$$+\frac{A}{\mu}(b_n M_n + b_s M_s)\{N_s[T - T_s(1-\alpha^{\alpha\epsilon})] + N_n[T - T_n^*(1-\alpha^{\alpha\epsilon})]\}. \quad (8)$$

We can easily check that $W(T_s)$ is concave in T_s, i.e., $\mathrm{d}^2W/\mathrm{d}T_s^2 < 0$ for all T_s. (Simply note that $\mathrm{d}W/\mathrm{d}T_s$ decreases with T_s.)

We next check if $\mathrm{d}W/\mathrm{d}T_s \geq 0$ at $T_s = T_n^*$. Substituting T_n^* for T_s in (8), then comparing the result with equation (4), we can show that it is indeed true that $\mathrm{d}W/\mathrm{d}T_s \geq 0$ at $T_s = T_n^*$. A formal proof is given in Appendix B. Defining the South's level of IPR protection that maximizes global welfare as $T_s^w \equiv \text{argmax } W(T_n = T_n^*)$, we conclude that $T_s^w > T_n^*$. Therefore, *given that the North continues to adopt its pre-TRIPS Nash equilibrium IPR standard, global welfare is maximized when the South adopts an IPR standard which is stronger than that of the North.* Refer to Figures 2A and 2B.

[Figures 2A and 2B about here]

Finally, we find that *the South's IPR protection that maximizes global welfare is an increasing function of the size of the South's market. Mathematically, we have* $\partial T_s^w/\partial N_s > 0$. The proof is given in an appendix available from the authors upon request. Intuitively, as N_s increases, there is a higher demand for North-innovated goods in the South (profit spillover is stronger) as well as a greater additional variety of differentiated products developed by the South from strengthening IPR (variety spillover is also stronger), and therefore the magnitude of the positive inter-regional externality of the South's IPR protection is greater. This calls for an increase in the South's IPR protection to internalize the externality.

The above result is somewhat consistent with the conclusion of Deardorff (1992), who finds that when the fraction of the world that is weak in IPR protection is larger, it is globally optimal to extend the strong IPR protection to more of these countries. What was not addressed by Deardorff (1992), but has been addressed by us, is that the globally optimal level of IPR protection by the South would be higher than the pre-TRIPS standard of the North even when the South has lower innovative capability than that of the North.

To conclude this section, we note that, given that the North is committed to the minimum standard, T_n^*, it would not be practical for the North to require the South to adopt any higher standard than that. This means that we can treat T_n^* as the upper bound of the minimum standard that the North can ask the South to adopt. Given this constraint, the TRIPS Agreement can be regarded as maximizing global welfare by requiring the South to adopt the North's pre-TRIPS standard, T_n^*, rather than anything lower, as the minimum IPR standard. It is in this sense that the TRIPS agreement is optimal.

4 Multi-sectoral Negotiations

In this section, we analyze the merits of the TRIPS Agreement in the context of a multi-sectoral negotiation. We consider the case in which the North wants the South to increase its IPR protection while, in return, the South wants the North to lower its trade barriers to imports of traditional goods from the South. We have seen from previous analysis that while raising the IPR standard in the South from its Nash equilibrium level T_s^* to the North's Nash equilibrium level T_n^* is globally welfare-improving, the South itself loses from such an increase. To make the TRIPS Agreement incentive-compatible for the South, the North, which is the beneficiary region, has to compensate the South. While a lump sum income transfer from the North to the South would solve the incentive-compatibility problem theoretically, it is not practical. In the Uruguay Round, the South demanded increased access to the North's markets in which it has comparative advantage, such as textile products. This sector is represented by z in this model. In the model, increasing market access amounts to lowering tariff τ on the import of z. We will show that allowing better access to the North's market in exchange for the South's strengthening of IPR standard is not only a realistic channel to solve the incentive-compatibility problem of the TRIPS, but also superior to the (impractical) lump sum income transfer mechanism.

The steady state flow welfare associated with sector z in the North and the South are, respectively,

$$\begin{aligned} U_{zn}(\tau) &= \eta_n \left[p_n(z)\bar{z}_n + \frac{1}{2e}(a - p_n(z))^2 + \tau z_{sn} \right], \\ U_{zs}(\tau) &= \eta_s \left[p_s(z)\bar{z}_s + \frac{1}{2e}(a - p_s(z))^2 \right]. \end{aligned}$$

Again, with no discounting of the future, the steady state flow welfare can be the basis of welfare analysis.

Without cooperation/negotiation with the South, the North chooses a non-cooperative optimal tariff to maximize $U_{zn}(\tau)$. Given the market equilibrium outcome obtained in Section 2, we know that this optimal tariff is

$$\tau^* = \frac{e(1+\delta-\delta^2)(\bar{z}_s - \bar{z}_n)}{2(1+\delta)-\delta^2}.$$

The corresponding welfare for the North and the South when τ^* is imposed are denoted $U^*_{zn}(\tau)$ and $U^*_{zs}(\tau)$, respectively. It is easily seen that lowering τ will reduce the North's welfare in sector z but will increase the South's welfare in this sector:

$$\begin{aligned} \frac{\partial U_{zn}(\tau)}{\partial \tau} &= \frac{\eta_n}{e(1+\delta)}[e(1+\delta-\delta_s^2)z_{sn} - \tau] > 0 \quad \text{for} \quad \tau < \tau^*. \\ \frac{\partial U_{zs}(\tau)}{\partial \tau} &= -\frac{\eta_s}{(1+\delta)}(\bar{z}_s - z_{ss}) < 0 \quad \text{for all } \tau. \end{aligned}$$

Recalling that U_k is region k's welfare derived from all sectors excluding sector z, we denote U^*_k as the equilibrium U_k under the pre-TRIPS regime (i.e., when both regions choose their Nash equilibrium IPR levels, T_n^* and T_s^*, respectively), and define U_k^c as the equilibrium U_k under the post-TRIPS regime (i.e., when both regions choose the minimum standard equal to T_n^*).

To model the multi-sectoral negotiation, we assume that the two regions bargain simultaneously over whether the South adopts the North's pre-TRIPS IPR standard as well as over the level of τ. The Nash bargaining model is adopted. Any agreement and bargaining outcome is assumed to last forever. Therefore, with no discounting, welfare consideration in the bargaining can be based on steady state flow welfare. Without having τ lowered, the South will not raise its IPR standard. So, the threat point of the bargain is such that the South maintains its pre-TRIPS IPR standard, while the North maintains tariff τ^*. To solve the bargaining problem, the tariff τ is chosen to maximize the product of two expressions that are functions of the net welfare improvements in the two regions, viz.

$$(U_n^c + U_{zn} - U_n^* - U_{zn}^*)^{(1-\upsilon)}(U_s^c + U_{zs} - U_s^* - U_{zs}^*)^{\upsilon},$$

where $\upsilon \in [0,1]$ represents the South's bargaining power. For ease of exposition, let $\mathcal{N}(\tau) \equiv U_n^c + U_{zn} - U_n^* - U_{zn}^*$ and $\mathcal{S}(\tau) \equiv U_s^c + U_{zs} - U_s^* - U_{zs}^*$. It is clear that to satisfy the incentive-compatibility condition in the South, τ needs to be low enough for the South to gain sufficiently from the traditional sector to compensate for its loss in the differentiated-products sector. Since there is a natural lower bound, $\tau = 0$, for this policy, we need to assume that a, e and $\bar{z}_s - \bar{z}_n$ are sufficiently large. This will ensure that the traditional-good markets are sufficiently large, the optimal tariff τ^* is sufficiently large, and consequently, there are sufficient gains to the South from tariff-cutting by the North. This will in turn ensure that both $\mathcal{N}(\tau)$ and $\mathcal{S}(\tau)$ are positive.

To make sure that there indeed exists an interior solution to the bargaining game, we have to check that the welfare frontier is concave. The slope of the bargaining frontier is equal to $\mathrm{d}\mathcal{N}(\tau)/\mathrm{d}\mathcal{S}(\tau) = (\partial U_{zn}/\partial \tau)/(\partial U_{zs}/\partial \tau)$. First, the slope is equal to zero when $\tau = \tau^*$. Second, it can be easily shown that the slope is negative and increases in magnitude as τ decreases, i.e. as $\mathcal{S}(\tau)$ increases. This ensures that the frontier is strictly concave. So, if the first-order condition of the Nash bargaining yields $\tau^c \in [0, \tau^*]$, it is an optimal interior solution. Refer to Figure 3.

[Figure 3 about here]

When $\tau = 0$, the slope of the welfare frontier is equal to $(1 + \delta - \delta^2)/\delta$, which is less than one as long as $\delta > 1$. To simplify things by ensuring that tariff reduction by the North is always globally welfare-improving, we assume that $\delta > 1$, i.e. the South's market for traditional good is larger than the North's. Therefore, any decrease in τ leads to an increase in $\mathcal{S}(\tau)$ with a magnitude greater than that of the concomitant decrease in $\mathcal{N}(\tau)$, so that global welfare is improved.[16]

The bargaining problem is equivalent to choosing τ to maximize $(1-\upsilon)\ln(\mathcal{N}(\tau))+\upsilon\ln(\mathcal{S}(\tau))$, which yields the following first-order condition,

$$\frac{(1-\upsilon)}{\mathcal{N}(\tau)}\frac{\partial U_{zn}}{\partial \tau} + \frac{\upsilon}{\mathcal{S}(\tau)}\frac{\partial U_{zs}}{\partial \tau} = 0. \tag{9}$$

We are interested in how the bargaining outcome τ^c is affected by other factors and how global welfare is in turn affected by the bargaining outcome. First, it is straightforward to show that $\partial \tau^c / \partial \upsilon < 0$, that is, trade liberalization in the traditional-good sector in the North would be deeper when the South has more bargaining power. This is the usual outcome of Nash bargaining since a lower τ^c favors the South. Second, it can be easily shown that $\partial W / \partial \tau < 0$. That is, global welfare increases when the South has more bargaining power. This is because higher bargaining power for the South leads to deeper trade liberalization in the North, which improves global welfare.

We have seen that both an increase in T_s and a decrease in τ yield net gains to the world, which can then be split between the two regions through Nash bargaining. So, we

[16] In our model, it is possible that $N_n > N_s$ while $\eta_s > \eta_n$, as long as e_s is sufficiently smaller than e_n. This simply reflects the fact that the South's consumers have, relatively speaking, a lower propensity to consume new products and a higher propensity to consume traditional products than their counterparts in the North. Casual observation confirms the presumption that the North's market for new products is larger than the South's market, while the reverse is true for the market for traditional goods.

can say that *since bargaining leads to* $\mathcal{N}(\tau^c) > 0$ *and* $\mathcal{S}(\tau^c) > 0$, *both regions benefit from the multi-sectoral negotiation, of which the TRIPS Agreement is an outcome.* Although we interpret the TRIPS Agreement as one that requires all regions to adopt a minimum IPR protection standard as defined by the North's pre-TRIPS protection level, the above result can be generalized as follows: *Both regions benefit from a bargain that involves the South raising its IPR protection standard to a pre-specified level* $T_s \in [T_s^*, T_n^*]$ *(while the North does not lower its pre-TRIPS IPR protection standard) on the one hand, and the North liberalizing trade in its traditional good sector on the other hand.* The proof of this general result can be obtained by simply repeating the above analysis. This result means that even if the regions find it impossible (e.g., for political reasons) to enforce a drastic set of concessions (with T_s set to T_n^*), they can agree on a less drastic set of concessions (with $T_s \in [T_s^*, T_n^*]$) and still end up with mutual gains in a multi-sectoral negotiation.

Finally, we examine each region's marginal gain from *increase*s in T_s, for all $T_s \in [T_s^*, T_n^*]$. We have found in Section 3 that as long as $T_s \in [T_s^*, T_n^*]$, any increase in T_s would lead to an increase in U_n^c but a decrease in U_s^c (now we need to reinterpret U_k^c as the value of U_k when the South and the North adopt T_s and T_n^*, respectively), and the gain in the former outweighs the loss in the latter so that $U_n^c + U_s^c$ increases. We have also proved above that as long as $\tau \in [0, \tau^*]$, any decrease in τ would lead to an increase in U_{zs} but to a decrease in U_{zn}, and the gain in the former outweighs the loss in the latter so that $U_{zs}+U_{zn}$ increases. We have assumed that the traditional goods markets are sufficiently large and the differences between the regions in endowments of traditional good are sufficiently great that tariff-cutting in the North is sufficient to compensate the South for its increase in IPR protection. Consequently, we prove in Appendix C that *whenever the South is willing to increase* T_s, *the North is willing to reduce* τ. *On balance, as* T_s *increases, the marginal gain to the North is always positive (i.e.,* $\mathcal{N}(\tau)$ *would increase), but the marginal gain to the South is positive (i.e.,* $\mathcal{S}(\tau)$ *increases) only if* v *is sufficiently large or* $\mathcal{S}(\tau)$ *is sufficiently small.* This indicates that although raising the South's IPR protection T_s all the way to T_n^* is globally optimal and is in the best interest of the North, such a big move may not be in the South's best interest unless the South's bargaining power in the negotiation is sufficiently strong to elicit a large tariff reduction from the North. Otherwise, the South would prefer an agreement that requires $T_s = T_s^c < T_n^*$, since all the extra surplus from raising the IPR protection beyond T_s^c would accrue to the North. In other words, while both regions gain from the multi-sectoral negotiation, the South may be able to gain more if it has more freedom to choose the degree of IPR protection.

5 Summary and Conclusion

We find that it is globally welfare-improving for the South to increase its IPR protection above its (pre-TRIPS) Nash equilibrium level. Although this would hurt the South and benefit the North, the latter's gains are larger than the former's losses. Consequently, it can benefit both regions for the South to adopt the North's pre-TRIPS IPR standard, in exchange for the North lowering its import tariffs. We conclude, therefore, that the inclusion of IPR negotiations in GATT/WTO agendas is constructive.

We find that in the multi-sectoral negotiation it is globally optimal for the South to increase its IPR protection standard all the way to the North's level. However, it is not necessarily optimal for the South to do so. It is optimal for the South only if its bargaining power in the negotiation is sufficiently large to elicit a large enough tariff reduction by the North. Otherwise, the extra surplus generated from strengthened IPR protection will mostly benefit the North. In that case, if the South has the choice, it would prefer an agreement that binds it to a higher standard than before, but below that of the North. In other words, giving the South an "all-or-nothing" choice in either adopting the North's IPR standard or maintaining the old standard might diminish the South's gain from such a negotiation. It seems evident that the South was indeed presented with an "all-or-nothing" choice regarding IPR protection in the Uruguay Round of the GATT negotiations. If this is the case, we can say that the TRIPS Agreement requires the South to give up too much. It is therefore no wonder that many developing countries are not enforcing as high an IPR standard as the developed countries want while the developed countries seem to be retracting from their market access commitments. In spite of these seeming retractions, however, our result has demonstrated that both regions would still gain as long as they can eventually *willingly* enforce *some* bilateral concessions in both sectors. This again demonstrates the merits of multi-sectoral negotiations.

In future research, we hope to modify the existing model to a truly dynamic, and possibly general equilibrium one, and to consider interactions among trade policies, FDI policies and IPR policies in a unified model.

Appendix

A Proof of the Stability of the Nash Equilibrium

To see this, totally differentiate (3) and (4) with respect to T_s and T_n. Note that by writing M_s and M_n as functions of μ, (3) can be expressed as a function of μ and T_s only, and thus,

$$\mathrm{d}[LHS(3) - RHS(3)] = \frac{\partial}{\partial \mu}[LHS(3) - RHS(3)](N_s \mathrm{d}T_s + N_n \mathrm{d}T_n) - \frac{\partial}{\partial T_s} RHS(3)\mathrm{d}T_s = 0.$$

Since $(\partial/\partial\mu)[LHS(3) - RHS(3)] > 0$, and $(\partial/\partial T_s)RHS(3) < 0$, the following inequality holds for the South's reaction function:

$$\left|\frac{dT_n}{dT_s}\right| > \frac{N_s}{N_n}.$$

Similarly, for the North, we have

$$\mathrm{d}[LHS(4) - RHS(4)] = \frac{\partial}{\partial \mu}[LHS(4) - RHS(4)](N_s \mathrm{d}T_s + N_n \mathrm{d}T_n) - \frac{\partial}{\partial T_n} RHS(4)\mathrm{d}T_n = 0,$$

from which we conclude that the following inequality holds for the North's reaction function:

$$\left|\frac{dT_n}{dT_s}\right| < \frac{N_s}{N_n}.$$

Therefore, the South's reaction curve is steeper than the North's in the (T_s, T_n) space.

B Proof of $\frac{dW}{dT_s}|_{T_s=T_n^*} > 0$

Suppose $\widehat{T}_n$ solves

$$M_n[1 - (1+\alpha)\alpha^{\alpha\epsilon}] + M_s(1 - \alpha^{\alpha\epsilon}) = \frac{N_n A}{\mu}[T - T_n(1 - \alpha^{\alpha\epsilon})](b_n M_n + b_s M_s). \tag{A1}$$

where $M_n = \left(\frac{\mu}{a_n}\right)^{b_n}$ and $M_s = \left(\frac{\mu}{a_s}\right)^{b_s}$, where $\mu \equiv N_n T_n A$.

Comparing with equation (4), it is clear that $\widehat{T}_n > T_n^*$, since the North's reaction function is downward sloping, so that T_n increases as T_s decreases to 0. Now suppose $\widehat{T}'_n$ solves

$$M_n[1-(1+\alpha)\alpha^{\alpha\epsilon}] + M_s(1-(1+\alpha)\alpha^{\alpha\epsilon}) = \frac{N_n A}{\mu}[T - T_n(1-\alpha^{\alpha\epsilon})](b_n M_n + b_s M_s). \tag{A2}$$

where $M_n = \left(\frac{\mu}{a_n}\right)^{b_n}$ and $M_s = \left(\frac{\mu}{a_s}\right)^{b_s}$, where $\mu \equiv N_n T_n A$.

We know that $\widehat{T}'_n > \widehat{T}_n$. This is because $LHS(A2) < LHS(A1)$, while $RHS(A2) = RHS(A1)$. Now, suppose $\widetilde{T}_n$ solves

$$M_n[1-(1+\alpha)\alpha^{\alpha\epsilon}] + M_s(1-(1+\alpha)\alpha^{\alpha\epsilon}) = \frac{(N_s+N_n)A}{\mu}[T - T_n(1-\alpha^{\alpha\epsilon})](b_n M_n + b_s M_s). \tag{A3}$$

where $M_n = \left(\frac{\mu}{a_n}\right)^{b_n}$ and $M_s = \left(\frac{\mu}{a_s}\right)^{b_s}$, where $\mu \equiv (N_s + N_n)T_n A$.

We can prove that $\widetilde{T}_n > \widehat{T}'_n$. The proof is given below. Define $P \equiv A[T - T_s(1-\alpha^{\alpha\epsilon})]b_s$; $Q \equiv [1-(1+\alpha)\alpha^{\alpha\epsilon}]$; $R \equiv A[T - T_s(1-\alpha^{\alpha\epsilon})]b_n$ and $S \equiv (1-\alpha^{\alpha\epsilon})$. Equation (A2) can be written as

$$M_s\left(\frac{P}{AT_n} - Q\right) + M_n\left(\frac{R}{AT_n} - Q\right) = 0, \tag{A4}$$

where $M_n = \left(\frac{\mu}{a_n}\right)^{b_n}$ and $M_s = \left(\frac{\mu}{a_s}\right)^{b_s}$, where $\mu \equiv N_n T_n A$.

Now, we have

$$\begin{aligned}
\frac{\partial LHS(A4)}{\partial N_n} &= \frac{\partial M_s}{\partial N_n}\left(\frac{P}{AT_n} - Q\right) + \frac{\partial M_n}{\partial N_n}\left(\frac{R}{AT_n} - Q\right) \\
&= \frac{M_s}{\mu} b_s T_n A\left(\frac{P}{AT_n} - Q\right) + \frac{M_n}{\mu} b_n T_n A\left(\frac{R}{AT_n} - Q\right) \\
&= \frac{M_s}{\mu} b_s T_n A\left(\frac{P}{AT_n} - Q\right) - \frac{M_s}{\mu} b_n T_n A\left(\frac{P}{AT_n} - Q\right) \\
&= \frac{M_s}{\mu} T_n A(b_s - b_n)\left(\frac{P}{AT_n} - Q\right)
\end{aligned}$$

The third line of the above equation comes from using equation (A4). We are now ready to prove that the last line is greater than zero. If $b_n > b_s$, then equation (A4) indicates that $\frac{R}{AT_n} - Q > 0 > \frac{P}{AT_n} - Q$ since the two expressions must be of opposite signs;

on the other hand, if $b_n < b_s$, then equation (A4) indicates that $\frac{R}{AT_n} - Q < 0 < \frac{P}{AT_n} - Q$. Both cases imply that the last line is greater than zero. Therefore, $\frac{\partial LHS(A4)}{\partial N_n} > 0$.

Now, it is quite clear that $\frac{\partial LHS(A4)}{\partial T_n} < 0$. Therefore, by the Implicit Function Theorem, we conclude that $\frac{\mathrm{d}T_n}{\mathrm{d}N_n} > 0$ for equation (A4) to hold. Now, (A3) is obtained from (A2) by changing N_n to $N_s + N_n$. Therefore, we can conclude that $\widetilde{T}_n > \widehat{T}'_n > \widehat{T}_n > T^*_n$. Since $(\partial/\partial T_n)[RHS(A3) - LHS(A3)] < 0$, and $RHS(A3) - LHS(A3) = 0$ at $T_n = \widetilde{T}_n$, it follows that $RHS(A3) - LHS(A3) > 0$ at $T_n = T^*_n$. Since $RHS(8)$(at $T_s = T^*_n$) $= RHS(A3) - LHS(A3)$ (at $T_n = T^*_n$), we conclude that $\frac{dW}{dT_s}|_{T_s = T^*_n} > 0$.

C $\mathrm{d}\mathcal{N}/\mathrm{d}T_s$ and $\mathrm{d}\mathcal{S}/\mathrm{d}T_s$

Note that

$$\mathrm{d}\mathcal{S} = \mathrm{d}U^c_s + \mathrm{d}U_{zs} \quad \text{and} \quad \mathrm{d}\mathcal{N} = \mathrm{d}U^c_n + \mathrm{d}U_{zn}.$$

From the analysis in Section 3, we have

$$\frac{\mathrm{d}U^c_s}{\mathrm{d}T_s} < 0, \ \frac{\mathrm{d}U^c_n}{\mathrm{d}T_s} > 0, \ \left|\frac{\mathrm{d}U^c_s}{\mathrm{d}T_s}\right| < \left|\frac{\mathrm{d}U^c_n}{\mathrm{d}T_s}\right|.$$

From the analysis in Section 4, we have

$$\frac{dU_{zs}}{d\tau} < 0, \ \frac{dU_{zn}}{d\tau} > 0, \ \left|\frac{dU_{zs}}{d\tau}\right| > \left|\frac{dU_{zn}}{d\tau}\right| .$$

From equation (9), we have

$$\mathcal{S}(\tau)(1-\upsilon)\frac{\mathrm{d}U_{zn}}{\mathrm{d}U_{zs}} + \mathcal{N}(\tau)\upsilon = 0.$$

Since we want to find the effect of changes in U^c_n (due to changes in T_s) on $\mathcal{S}$ and $\mathcal{N}$, we totally differentiate the above equation with respect to τ and any other variables that are affected by T_s and τ.

$$(1-\upsilon)\frac{\mathrm{d}U_{zn}}{\mathrm{d}U_{zs}}d\mathcal{S} + \mathcal{S}(\tau)(1-\upsilon)\frac{\mathrm{d}}{\mathrm{d}\tau}\left(\frac{\mathrm{d}U_{zn}}{\mathrm{d}U_{zs}}\right)\mathrm{d}\tau + \upsilon\mathrm{d}\mathcal{N} = 0,$$

which implies

$$(1-\upsilon)\frac{dU_{zn}}{dU_{zs}}(dU^c_s + dU_{zs}) + \mathcal{S}(\tau)(1-\upsilon)\frac{d}{d\tau}\left(\frac{dU_{zn}}{dU_{zs}}\right)d\tau + \upsilon(dU^c_n + dU_{zn}) = 0.$$

Note that changes in U_n^c and U_s^c are due to T_s while changes in U_{zn} and U_{zs} are due to τ. An increase in T_s leads to an increase in U_n^c and a decrease in U_s^c, thus prompting the North to decrease τ in the tariff negotiation, which in turn leads to an increase in U_{zs} and a decrease in U_{zn}, as will be shown below. Differentiating the equation with respect to T_s, we have

$$(1-\upsilon)\frac{\mathrm{d}U_{zn}}{\mathrm{d}U_{zs}}(\frac{\mathrm{d}U_s^c}{\mathrm{d}T_s}+\frac{\mathrm{d}U_{zs}}{\mathrm{d}\tau}\frac{\mathrm{d}\tau}{\mathrm{d}T_s})+\mathcal{S}(\tau)(1-\upsilon)\frac{\mathrm{d}}{\mathrm{d}\tau}\left(\frac{\mathrm{d}U_{zn}}{\mathrm{d}U_{zs}}\right)\frac{\mathrm{d}\tau}{\mathrm{d}T_s}+\upsilon(\frac{\mathrm{d}U_n^c}{\mathrm{d}T_s}+\frac{\mathrm{d}U_{zn}}{\mathrm{d}\tau}\frac{\mathrm{d}\tau}{\mathrm{d}T_s})=0.$$

Let $Y\equiv\left|\frac{dU_{zn}}{dU_{zs}}\right|>1$. Recall that $\frac{dU_{zn}}{dU_{zs}}<0$. From the above equation, we can solve for

$$\frac{\mathrm{d}\tau}{\mathrm{d}T_s}=\frac{(1-\upsilon)\frac{dU_s^c}{dT_s}Y-\upsilon\frac{dU_n^c}{dT_s}}{(1-\upsilon)\left[-Y\frac{dU_{zs}}{d\tau}-\mathcal{S}\frac{dY}{d\tau}\right]+\upsilon\frac{dU_{zn}}{d\tau}}<0.$$

Therefore,

$$\frac{\mathrm{d}\mathcal{S}}{\mathrm{d}T_s}=\frac{\mathrm{d}U_s^c}{\mathrm{d}T_s}+\frac{\mathrm{d}U_{zs}}{\mathrm{d}\tau}\cdot\frac{\mathrm{d}\tau}{\mathrm{d}T_s}=\frac{-(1-\upsilon)\mathcal{S}\frac{dU_s^c}{dT_s}\frac{dY}{d\tau}+\upsilon\frac{dU_s^c}{dT_s}\frac{dU_{zn}}{d\tau}-\upsilon\frac{dU_n^c}{dT_s}\frac{dU_{zs}}{d\tau}}{(1-\upsilon)\left[-Y\frac{dU_{zs}}{d\tau}-\mathcal{S}\frac{dY}{d\tau}\right]+\upsilon\frac{dU_{zn}}{d\tau}}.$$

On the RHS of the above equation, the denominator is always positive. However, the numerator is greater than zero only if υ is sufficiently large or when $\mathcal{S}$ is sufficiently small, based on the inequalities obtained at the beginning of the proof and $\frac{\mathrm{d}Y}{\mathrm{d}\tau}<0$. Hence, the expression is positive if υ is sufficiently large or $\mathcal{S}$ is small. When $T_s=T_s^*$, $\tau=\tau^*$, and $\mathcal{S}=0$. Therefore, $\frac{\mathrm{d}\mathcal{S}}{\mathrm{d}T_s}>0$ at $T_s=T_s^*$. Given that, as T_s increases, $\left|\frac{dU_s^c}{dT_s}\right|$and $\left|\frac{dY}{d\tau}\right|$ both increase, while $\left|\frac{dU_n^c}{dT_s}\right|-\left|\frac{dU_s^c}{dT_s}\right|$ decreases, and $\left|\frac{dU_{zs}}{d\tau}\right|-\left|\frac{dU_{zn}}{d\tau}\right|$ decreases, we conclude that $\frac{d\mathcal{S}}{dT_s}$ gets smaller as T_s increases. Therefore, $\mathcal{S}$ is maximized as T_s increases to a certain level. This level may not be much higher than T_s^* if υ is small. Thus, if υ is small, it is optimal for the South to increase its IPR protection only slightly. From the South's point of view, it is optimal to increase IPR protection all the way to T_n^* only when υ is sufficiently large so that $\frac{d\mathcal{S}}{dT_s}>0$ for any $T_s\in[T_s^*,T_n^*]$.

On the other hand,

$$\frac{\mathrm{d}\mathcal{N}}{\mathrm{d}T_s}=\frac{\mathrm{d}U_n^c}{\mathrm{d}T_s}+\frac{\mathrm{d}U_{zn}}{\mathrm{d}\tau}\cdot\frac{\mathrm{d}\tau}{\mathrm{d}T_s}=\frac{(1-\upsilon)\left[-Y\frac{dU_n^c}{dT_s}\frac{dU_{zs}}{d\tau}+Y\frac{dU_n^c}{dT_s}\frac{dU_{zn}}{d\tau}-\mathcal{S}\frac{dY}{d\tau}\frac{dU_n^c}{dT_s}\right]}{(1-\upsilon)\left[-Y\frac{dU_{zs}}{d\tau}-\mathcal{S}\frac{dY}{d\tau}\right]+\upsilon\frac{dU_{zn}}{d\tau}}>0,$$

because both the denominator and numerator are positive, based on the inequalities obtained at the beginning of the proof and $\frac{dY}{d\tau}<0$.

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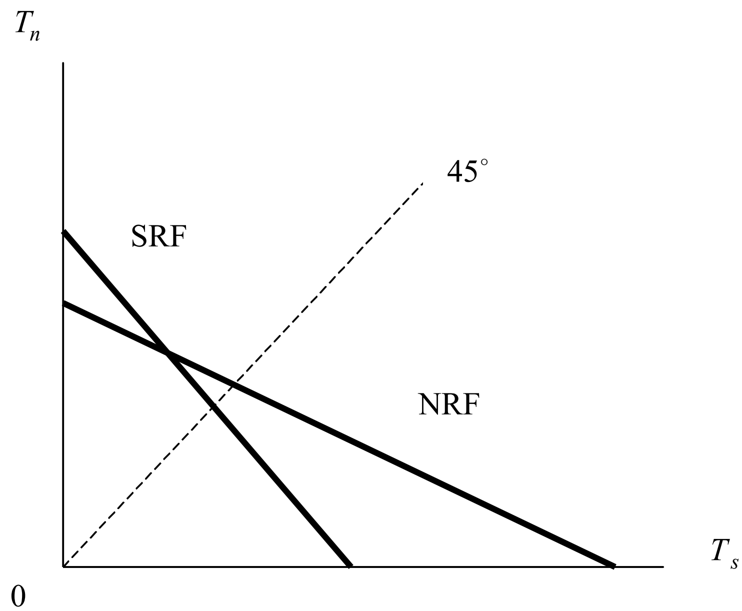

Figure 1. **Pre-TRIPS Nash Equilibrium IPR standards.** NRF indicates the North's reaction function, while SRF indicates the South's reaction function.

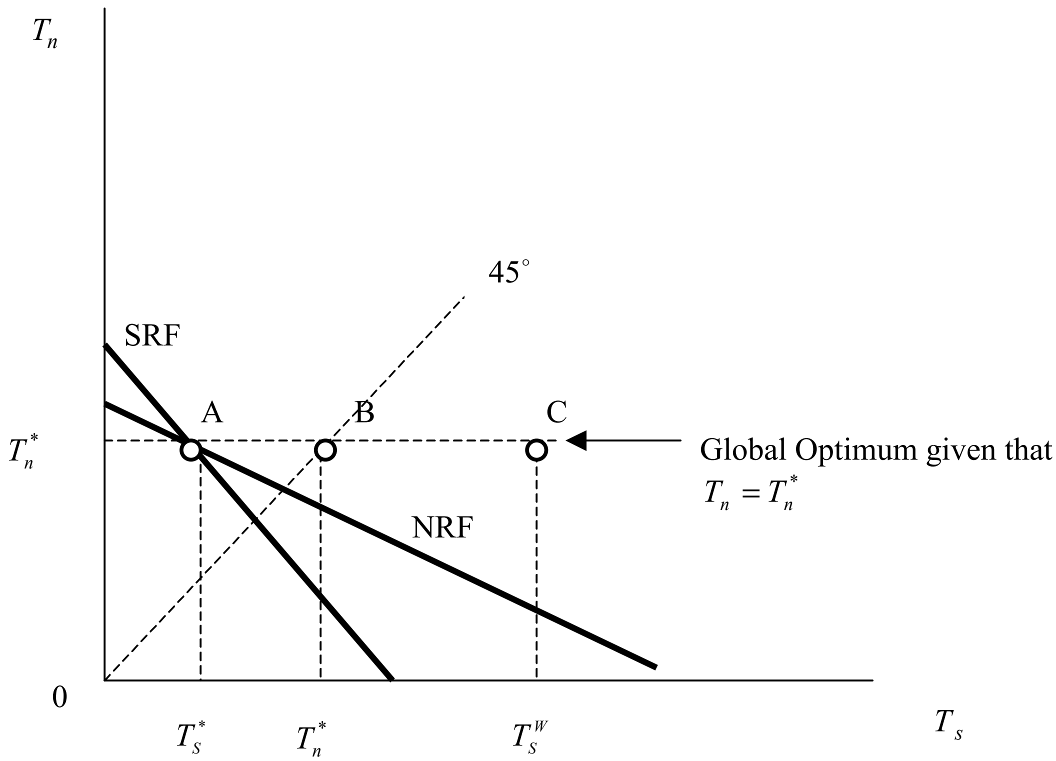

Figure 2A. The TRIPS versus global optimum. TRIPS moves the world from A to B, but the optimum is at C, given that $T_n = T_n^*$. Here, T_S^* indicates the South's pre-TRIPS patent length; T_n^* indicates the North's pre-TRIPS patent length; T_S^W indicates the South's patent length that would maximize global welfare given that the North keeps its pre-TRIPS patent length.

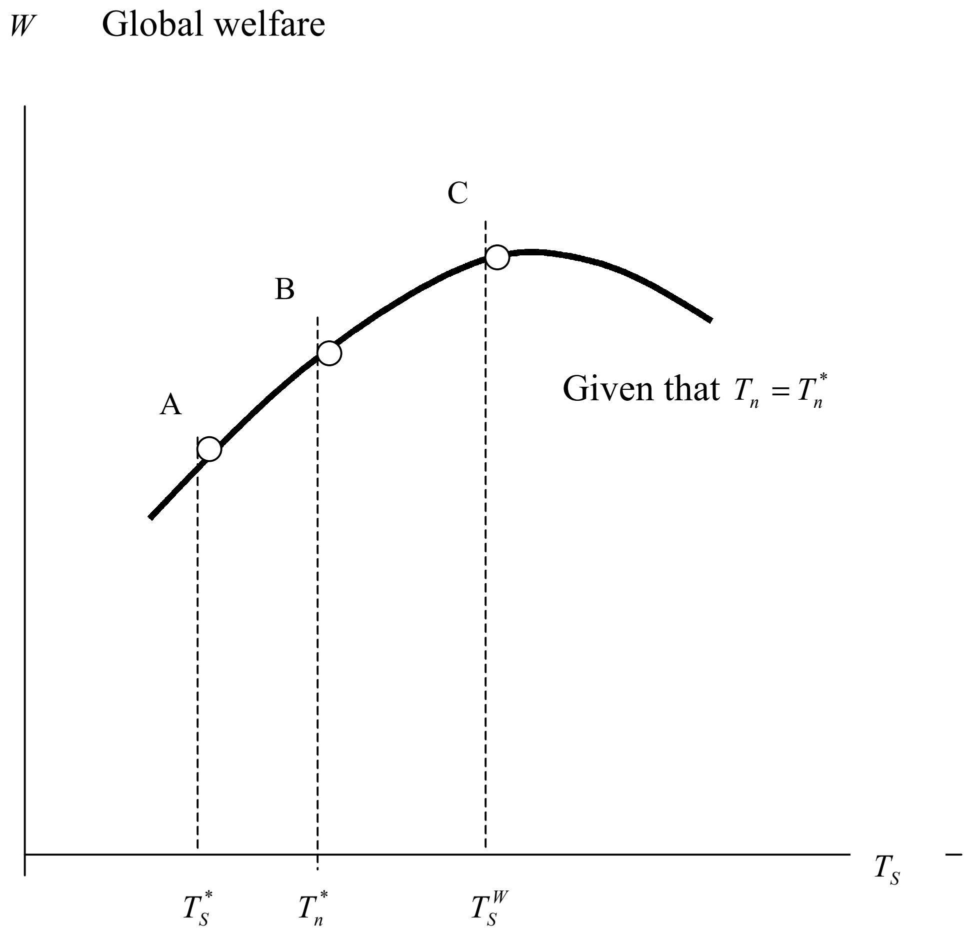

Figure 2B. World welfare as South's patent length changes. Points A, B and C correspond to those in Figure 2A.

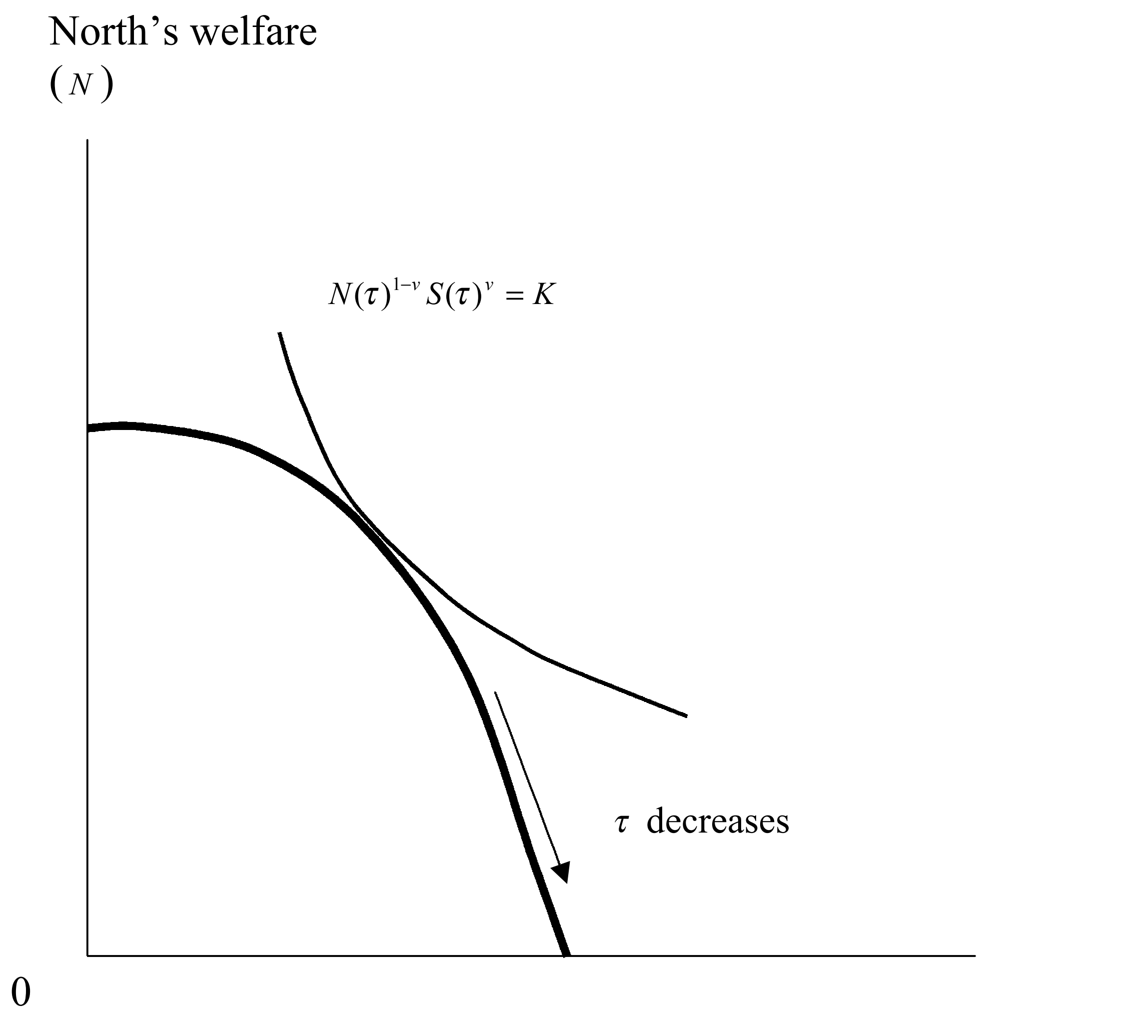

Figure 3. **Nash Bargaining over τ.** The two regions bargain simultaneously over whether the South adopts the North's pre-TRIPS IPR and over the value of τ. The origin is the point with no agreement.