Northern Intellectual Property Rights Standards for the South?

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Abstract

We build a theoretical model to compare the optimal intellectual property rights (IPR) protection standards of the South (the less developed world) with the IPR standards that the North (the more developed world) is committed to. We find that it is in the South's interest to adopt a less stringent IPR standard in the South than that of the North. Although it is globally optimal for the South to increase its IPR protection above its individually optimal level, it is globally optimal for the South to adopt a weaker IPR standard than that of the North. Finally, under certain conditions, the world is worse off forcing the South to adopt the Northern standard than allowing the South to adopt its own optimal standard.

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Northern Intellectual Property Rights Standards for the South?

1 Introduction

In the Uruguay Round of the General Agreement on Tariffs and Trade, the participating countries agreed to adopt a set of universal minimum standards of intellectual property rights (IPR) protection. This agreement, contained in annex 1C, is called the Agreement on Trade-Related Aspects of Intellectual Property Rights (the TRIPs Agreement). It basically supplements the World Intellectual Property Organization (WIPO) Conventions on intellectual property, with substantive obligations and disciplines within the World Trade Organization (WTO). To many observers, most of the terms of the agreement are backward-looking, based on the prevailing Northern standards at the time of the negotiation (e.g. Reichman, 1995). According to this agreement, many LDCs would have to substantially strengthen the legal protection to IPR.[1]

There are two major obligations for the member countries. First, 'national treatment' requires that all members must treat nationals of other countries no less favorably than their own nationals on all matters concerning intellectual property rights. Second, the 'most-favored nation' treatment requires that any advantage a member grant to the nationals of any other country must be extended to all other WTO members. The agreement also calls for substantial strengthening of administrative and enforcement procedures.

In this paper, we would like to evaluate the consequences of the TRIPS agreement, which we interpret as one that forces the South to adopt the prevailing IPR standards of the North just before the agreement was signed.

There are several relevant questions. First, does the South (and the world) gain from increasing its IPR protection above its pre-TRIPS level? Second, does the South (and the world) gain from increasing its pre-TRIPS level of IPR protection to the Northern level? Third, from the global welfare point of view, does the South protect too much or too little when it adopts Northern IPR standards? There are obvious policy implications of these issues. For example,

[1] For example, the agreement stipulates patent length of twenty years for the pharmaceutical industry, whereas a country like India only protects pharmaceutical patents for seven years, with compulsory licensing during the protection period.

if it is globally optimal for the South to adopt Northern IPR standards, then the world would be better off if there is a quid pro quo between the two regions: the South adopting Northern IPR protection standards while the North allows its market to be more accessible to Southern goods. On the other hand, if it is both individually and globally optimal for the South not to protect IPR at all, then the grounds for forcing the South to adopt Northern IPR standards are much weakened.

There have been various efforts to study both theoretically and empirically the effects of IPR protection on trade (Maskus and Penubarti 1995), FDI (Mansfield 1996, Lai 1998), innovation (Mansfield 1986, Lai 1998, Horowitz and Lai 1996) and economic growth (Gould and Gruben 1996, Lai 1998). Deardorff (1992) and Helpman (1993) are notable examples of theoretical study of the global welfare impact of Southern IPR protection. Chin and Grossman (1990) study the global welfare effects of IPR protection in the South in a very simple model of cost-reducing innovation in a single product line only. They only compare the two extreme cases of 'protect' and 'not protect' in the South. We believe, however, that the key issue is not whether the South should protect IPR or not, but *how much* they should protect.

Lai (1998) analyzes how the global rate of technological progress is affected by IPR protection in the South, if the North specializes in innovation and the South specializes in imitation, as in a product cycle model. Since stronger IPR protection in the South can increase the rate of innovation, there is a tradeoff between the dynamic gains and static losses from strengthening IPR protection in the South. However, because the focus is on the rate of innovation and imitation, no explicit analysis of optimal protection is undertaken in the paper.

The approach of this paper is as follows. We build a theoretical model, in which we assume: the South has no innovative capability and does not protect IPR at all before TRIPS; the South is forced, through TRIPS, to adopt the IPR standards that the North has been adopting before TRIPS. We then ask: what is the individually (and globally) optimal IPR protection in the South given what the North is committed to? How do they compare with the Northern standard?

Our major findings are: (1) As long as the Southern market is sufficiently large compared with that of the North, it is optimal for the South to protect IPR even if the South has no innovative capability at all. (2) However, it would never be optimal for the South to adopt an IPR standard as stringent as that of the North. This is because the South takes into account the committed Northern IPR protection and trade opportunity when evaluating its optimal protection, and the South does not benefit from the additional profits accrued to Northern firms as Southern IPR protection is strengthened. (3) If the world has to adopt a unified IPR standard, the globally optimal one is the pre-TRIPS Northern standard. However, given that the North is committed to its pre-TRIPS standard, it is globally optimal for the South to adopt an IPR standard below the Northern standard. This finding points to the shortfall of unifying the IPR standards of the world when the more innovative region has committed to an optimal IPR standard of its own. (4) Under certain conditions (for example, when the Southern market is much smaller than that of the North), global welfare will be lower by forcing the South to adopt the Northern standard than allowing the South to adopt its individually optimal standard.

As far as we are aware of, our paper is one of the first to endogenize the optimal degree of IPR protection in the North, South and the world respectively. Our paper differs from Chin and Grossman (1990) in that (a) we allow for product innovation rather than process innovation; (b) we consider a monopolistically competitive world industry, with free entry and exit, rather than duopolistic competition between a Southern firm and a Northern firm; (c) when we analyze IPR protection in a country, we consider not just whether the country 'protects' or 'does not protect' IPR, but the optimal degree of protection in the country. Whereas Chin and Grossman find that it is optimal for the South to protect IPR when its market is sufficiently large, we find that it is optimal for the South to protect more when its market is larger, but the South never have the incentive to protect as strongly as the North does.

The differences between our paper and Deardorff's (1992) are (a) free entry and exit of firms; (b) we allow each country's government to choose an optimal level of IPR protection. While Deardorff finds that it is globally optimal for the South to protect IPR when it is large relative to the North, we find that it is never globally optimal for the South to adopt as strong a standard as that of the North.

Unlike Helpman (1993), our model is a partial equilibrium one, with a more detailed microeconomic analysis of firm and government behavior. For example, our model differs from Helpman in that an imitated products produced in the South cannot be sold in the North until IPR protection in the North expires. Helpman, however, assumes that a South-imitated product can be sold in North even before the Northern patent expires in North.

The policy implications are as follow. Although the South has very low capability to innovate, it has incentive to protect IPR if the Southern market is sufficiently large. In those markets, we argue for increasing Southern IPR protection beyond its individually optimal level (but only up to a point) for the sake of global welfare, since the losses to the South of doing that can be more than compensated by the gains in the North. However, the globally optimal IPR protection in the South is somewhere between the Southern optimal and Northern optimal level. Therefore, it may very well be best for the North to strike a compromise with the South rather than forcing the South to adopt its own IPR standards.

However, in certain industries, where the Southern market is much smaller than that of the North or the Southern innovative capability is much lower than that of the North, it may well be globally welfare-improving for the South not to protect IPR at all rather than adopting Northern standard, since the losses to the South of adopting Northern standards cannot be compensated by the gains by the North.

The organization of the paper is as follows. Section 2 lays out the basic features of the model and derives the optimal IPR protection levels in the North and the South, assuming that the North was committed to a level of IPR protection before the South possessed any significant technological capability. Section 3 analyzes the properties of the optimal Southern IPR protection level, and compares it with that of the North. Section 4 analyzes the effect of Southern IPR protection on global welfare. The properties of the globally optimal Southern protection is also analyzed. Section 5 summarizes and discusses the results.

2 The Model and Analysis

There are two regions in the world, the North and the South. We distinguish beteen two distinct regimes, with regime 1 representing the pre-TRIPS era and regime 2 the post-TRIPS era. To put things in sharper contrast, we assume that the North has high capability of innovation while the South is incapable of inventing any products. Moreover, we assume that there is no IPR protection in the South while the North establishes and commits to an IPR standard in regime 1. In regime 2, the South is forced to adopt the IPR standard that the North is committed to in regime 1. This, we interpret, is what is stipulated in the TRIPS agreement. We then ask: what is the individually (and globally) optimal IPR protection in the South given what the North is committed to? How do they compare with the Northern standard?

2.1 Regime 1 (pre-TRIPS): Optimal IPR Protection in the North

Consider an industry where innovation occurs very frequently. We assume that the South has no ability to innovate and that it does not protect IPR in any industry in this regime.[2] Therefore, there is no trade between the North and the South, and new products are only invented in the North. Assume that any newly invented product will become obsolete after T periods.[3] The Northern government sets its patent length T_n to protect new products from being imitated in the region. Then all potential innovators decide whether to make their individual R&D investments, and if they do, new products will be developed. We call the innovator of product i Northern firm i. Given T_n, let M be the number of new products introduced to the market. Although the number of products are finite, we assume that they are continuous in our mathematical derivation for easier handling. When the IPR protection expires, all products will be imitated and the imitation cost is assumed to be zero. Assume that there are N_n identical consumers in the North and the representative consumer's utility in period t is:

$$u_n(t) = \int_0^M x_{nn}(i)^\alpha \mathrm{d}i + y_n, \quad 0 < \alpha < 1,$$

where $x_{nn}(i)$ is the quantity of the new product i consumed by the representative consumer ($x_{nn}(i) = 0$ if product i is not invented or there is no consumption of it), and y_n is the traditional good with the price equal to one. Each consumer maximizes the utility subject to budget constraint $I_n \geq \int_0^M p_{nn}(i)x_{nn}(i)\mathrm{d}i + y_n$ where $p_{nn}(i)$ is the price of product i and the expenditure I_n is exogenously given. For notation simplicity, define $\epsilon = 1/(1-\alpha)$ and $A = (1-\alpha)\alpha^{(1+\alpha)\epsilon}$. Then, the derived demand function by the representative consumer is

$$x_{nn}(i) = [\frac{p_{nn}(i)}{\alpha}]^{-\epsilon}.$$

Thus, the aggregate demand for product i in the North is

$$X_{nn}(i) = N_n[\frac{p_{nn}(i)}{\alpha}]^{-\epsilon}.$$

[2]We do not attempt to explain why the South does not protect IPR but simply take it as a given fact. The assumptions are basically consistent with the fact that at the time the TRIPS agreement was signed.

[3]T can be regarded as the length of the product cycle — after T periods, all previously developed products are completed replaced by better products.

For simplicity, assume that the marginal cost of production is constant and equal to one for all products. Then, Northern firm i's operational profit (i.e., profit not including innovation costs) is $\pi_{nn}(i) = [p_{nn}(i) - 1]X_{nn}(i)$. Under the IPR protection, firm i is a monopoly in product i. As a result, in every period $t \leq T_n$,

$$p_{nn}(i) = \frac{1}{\alpha}, \;\; X_{nn}(i) = N_n \alpha^{2\epsilon}, \;\; \pi_{nn}(i) = N_n A.$$

In every period $t > T_n$, because of (costless) imitation,

$$p_{nn}(i) = 1, \;\; X_{nn}(i) = N_n \alpha^{\epsilon}, \;\; \pi_{nn}(i) = 0.$$

As a result, the representative consumer's utility is

$$u_n(t) = M(1-\alpha)\alpha^{2\alpha\epsilon} + I_n, \quad \text{for } \; t \leq T_n;$$

$$u_n(t) = M(1-\alpha)\alpha^{\alpha\epsilon} + I_n, \quad \text{for } \; t > T_n.$$

We now turn to firms' profits. Because of the IPR protection, any one good is produced by one firm only. Because of diminishing returns to innovation (sometimes called the 'fishing out' problem), the marginal cost of innovation increases with the number of developed products. We index goods in ascending order of 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 firm i is $i^{1/b}$ where $0 < b < 1$, with $1/b$ being the elasticity of marginal innovation cost with respect to product variety.[4] It is also a proxy for the marginal cost of innovation for a given level of product diversity. To simplify the analysis, we assume that there is no discount of the future.[5] Then, firm i's total profit is

$$\Pi_n(i) = \int_0^{T_n} \pi_{nn}(i)\mathrm{d}t - i^{\frac{1}{b}} = N_n T_n A - i^{\frac{1}{b}}.$$

The marginal firm, M, is defined as the one that earns zero profit, i.e., $\Pi_n(M) = 0$. This leads to

$$M = m^b, \quad \text{where } \; m \equiv N_n T_n A.$$

[4]We could instead use a more general cost function such as $a + \gamma i^{1/b}$ where $\gamma > 0$; or more generally, $f(i)$, where $f(0) \geq 0$, $f'(.) > 0$. But our results will not be altered qualitatively.

[5]Our results will not be affected qualitatively even if the future is discounted.

Thus, all products with $i \leq M$ are invented and

$$\frac{\partial M}{\partial b} = m^b \ln(m) > 0,$$

as long as $m > 1$. Moreover,

$$\frac{\partial M}{\partial T_n} = bm^{b-1}AN_n > 0, \quad \frac{\partial^2 M}{\partial T_n^2} = b(b-1)m^{b-2}A^2N_n^2 < 0.$$

The welfare function of the North, denoted by $W_n(T_n)$ or $w_n(T_n, M)$, is defined as the sum of consumer utility and producer profits, which is given as

$$W_n(T_n) = w_n(T_n, M) = N_n \int_0^{T_n} u_n(t)\mathrm{d}t + N_n \int_{T_n}^{T} u_n(t)\mathrm{d}t + \int_0^M \Pi_n(i)\mathrm{d}i$$

$$= N_n T_n M(1-\alpha)\alpha^{2\alpha\epsilon} + N_n(T - T_n)M(1-\alpha)\alpha^{\alpha\epsilon} + N_n T I_n + \frac{1}{1+b} M^{\frac{1+b}{b}}.$$

We assume that the Northern government's objective is to maximize the Northern welfare by choosing T_n. Assuming interior solution, the first order condition for optimal T_n is

$$\frac{\mathrm{d}W_n}{\mathrm{d}T_n} = \frac{\partial w_n}{\partial T_n} + \frac{\partial w_n}{\partial M}\frac{\partial M}{\partial T_n} = 0.$$

Note that

$$\frac{\partial w_n}{\partial T_n} = -N_n M[1 - (1+\alpha)\alpha^{\alpha\epsilon}](1-\alpha)\alpha^{\alpha\epsilon} < 0.$$

This is the marginal effect of lengthening IPR protection for existing products. It is the sum of consumer losses and producer gains, which adds up to a deadweight loss. This is the social marginal cost of IPR protection, denoted by MC$\equiv |\partial w_n / \partial T_n|$. The magnitude of MC increases as T_n increases:

$$\frac{\partial \mathrm{MC}}{\partial T_n} = N_n \frac{\partial M}{\partial T_n}[1 - (1+\alpha)\alpha^{\alpha\epsilon}](1-\alpha)\alpha^{\alpha\epsilon} > 0.$$

On the other hand, lengthening IPR protection encourages more innovations, which enlarging product variety and so raises consumer welfare. This is the social marginal benefit (MB) of increasing T_n:

$$\mathrm{MB} \equiv \frac{\partial w_n}{\partial M}\frac{\partial M}{\partial T_n} = N_n[T - T_n(1 - \alpha^{\alpha\epsilon})](1-\alpha)\alpha^{\alpha\epsilon}\frac{\partial M}{\partial T_n} > 0.$$

It is easy to check that the MB decreases as T_n increases.

(FIGURE 1 IS ABOUT HERE)

The optimal IPR protection in the North, denoted by T_n^*, is chosen such that MC=MB, as in Figure 1.[6] With the above analysis, the first order condition reduces to[7]

$$T_n[1-(1+\alpha)\alpha^{\alpha\epsilon}] = [T - T_n(1-\alpha^{\alpha\epsilon})]b, \tag{1}$$

where

$$\text{LHS} = \frac{\text{MC}}{N_n^2 m^{b-1} A(1-\alpha)\alpha^{\alpha\epsilon}}, \quad \text{RHS} = \frac{\text{MB}}{N_n^2 m^{b-1} A(1-\alpha)\alpha^{\alpha\epsilon}}.$$

Solving equation (1) gives the optimal protection:

$$T_n^* = \frac{bT}{1-(1+\alpha+b)\alpha^{\alpha\epsilon}+b}. \tag{2}$$

To ensure an interior solution, we need to impose some constraints on the parameters. Using (2), a necessary and sufficient condition for $T_n^* > 0$ is $1 + b - (1+\alpha+b)\alpha^{\alpha\epsilon} > 0$, which is automatically satisfied, and the necessary and sufficient condition for $T_n < T$ is:

Constraint 1: $1-(1+\alpha+b)\alpha^{\alpha\epsilon} > 0$.

This latter condition requires that b is not too big. When b increases, both the MC and MB are higher. But if b is too big, a small increase in the IPR protection will induce a lot of innovations, i.e., the MB becomes much higher. It makes the North worthwhile to continue to raise protection until T. Graphically, in Figure 1, both the MC and MB curves shift up but the MB curves shifts up more. For a sufficiently large b, the MB curve will intersect the MC curve at $T_n \geq T$. We now have our first result:

Proposition 1 : *Under Constraint 1, the optimal length of IPR protection in the North is as given in (2), which is less than T. A decrease in the cost of innovation across all firms warrants stronger IPR protection, i.e., $\partial T_n^*/\partial b > 0$. Moreover, $\partial T_n^*/\partial T > 0$. That is, an increase in the length of the product cycle raises the optimal length of IPR protection.*

PROOF: Straightforward from (2). □

To see these results, first, recall that both the MC and MB curves shift upwards as b increases. However, the ratio of MB to MC increases as b increases, indicating that the impact of b on MB is larger than the impact on MC. Therefore, T_n^* increases. Second, an increase in T increases MB without affecting MC. Therefore, T_n^* increases with T.

[6] It can be shown that $\partial^2\text{MC}/\partial T_n^2 < 0$ and $\partial^2\text{MB}/\partial T_n^2 > 0$.

[7] The second order condition is automatically satisfied as it can be easily checked that $\mathrm{d}^2 W_n/\mathrm{d}T_n^2 < 0$.

2.2 Regime 2 (post-TRIPS): Optimal IPR Protection in the South

In this regime, the South is required to adopt the Northern standard, that is, $T_s = T_n^*$ is forced upon the South where T_s is the length of IPR protection in the South. In this section, we evaluate the individually optimal IPR standard of the South given that $T_n = T_n^*$. We also examine the condition under which the South benefits from increasing its IPR standard from $T_s = 0$ to $T_s = T_n^*$.

Suppose there are N_s identical consumers in the South. With trade in new products, the typical Southern consumer's utility in period t is:

$$u_s(t) = \int_0^{M_n} x_{ns}(i)^\alpha \mathrm{d}i + y_s, \quad 0 < \alpha < 1,$$

where $x_{ns}(i)$ is the amount of Northern product i consumed by this consumer in the Southern market, and y_s is the traditional good with price equal to one. Let $p_{ns}(i)$ be the price of the corresponding product in the Southern market. The consumer maximizes her utility subject to budget constraint $I_s \geq \int_0^{M_n} p_{ns}(i) x_{ns}(i)\mathrm{d}i + y_s$. The derived demand is

$$x_{ns}(i) = [\frac{p_{ns}(i)}{\alpha}]^{-\epsilon}.$$

Hence, the aggregate demand for Northern product i is

$$X_{ns}(i) = N_s[\frac{p_{ns}(i)}{\alpha}]^{-\epsilon}.$$

Assume for simplicity that the constant marginal cost of production is equal to one regardless of where a good is produced.[8] Thus, Northern firm i's operational profit from export is $\pi_{ns}(i) = [p_{ns}(i) - 1]X_{ns}(i)$. Under the IPR protection in the South, each firm is a monopolist in its product market. As a result, for $t \leq T_s$,

$$p_{ns}(i) = \frac{1}{\alpha}, \;\; X_{ns}(i) = N_s\alpha^{2\epsilon}, \;\; \pi_{ns}(i) = N_s A.$$

For $t > T_s$, imitation takes place in the South and therefore there is no demand for imports. However, products previously innovated by the North and now imitated by the South are still produced and traded in the Southern market. As a result, for $t > T_s$,

$$p_{ns}(i) = 1, \;\; X_{ns}(i) = N_s\alpha^{\epsilon}, \;\; \pi_{ns}(i) = 0.$$

[8] In general, labor cost is lower in the South than in the North while innovation cost is higher in the South than in the North. However, we emphasize the North-South difference in innovation costs here.

Therefore, the typical consumer's utility at time t is:

$$u_s(t) = M_n(1-\alpha)\alpha^{2\alpha\epsilon} + I_s, \quad \text{for } \ t \leq T_s;$$

$$u_s(t) = M_n(1-\alpha)\alpha^{\alpha\epsilon} + I_s, \quad \text{for } \ t > T_s.$$

The total profit of Northern firm i, is

$$\Pi_n(i) = \int_0^{T_n^*} \pi_{nn}(i)\mathrm{d}t + \int_0^{T_s} \pi_{ns}(i)\mathrm{d}t - i^{\frac{1}{b}} = (N_sT_s + N_nT_n^*)A - i^{\frac{1}{b}}.$$

The marginal firm in the North, M_n is defined as the ones that earn zero profit, i.e., $\Pi_n(M_n) = 0$. This leads to

$$M_n = \mu^b \quad \text{where } \ \mu \equiv (N_sT_s + N_nT_n^*)A.$$

Thus,

$$\frac{\partial M_n}{\partial b} = \mu^b \ln(\mu) > 0,$$

as long as $\mu > 1$. Moreover,

$$\frac{\partial M_n}{\partial T_s} = N_s b\mu^{b-1}A > 0, \quad \frac{\partial^2 M_n}{\partial T_s^2} = N_s^2 b(b-1)\mu^{b-2}A^2 < 0,$$

The welfare of the South, denoted by $W_s(T_s)$ or $w_s(T_s, M_s, M_n)$, is defined and given as

$$W_s(T_s) = w_s(T_s, M_s, M_n) = N_s \int_0^{T_s} u_s(t)\mathrm{d}t + N_s \int_{T_s}^{T} u_s(t)\mathrm{d}t\mathrm{d}i$$

$$= N_sT_s[M_n(1-\alpha)\alpha^{2\alpha\epsilon}] + N_s(T-T_s)[M_n(1-\alpha)\alpha^{\alpha\epsilon}] + N_sTI_s.$$

The Southern government's objective is to maximize the Southern welfare by choosing T_s. Assuming interior solution, the first order condition for optimal T_s is

$$\frac{\mathrm{d}W_s}{\mathrm{d}T_s} = \frac{\partial w_s}{\partial T_s} + \frac{\partial w_s}{\partial M_n}\frac{\partial M_n}{\partial T_s} = 0.$$

Note that

$$\frac{\partial w_s}{\partial T_s} = -N_s\{M_n(1-\alpha^{\alpha\epsilon})\}(1-\alpha)\alpha^{\alpha\epsilon} < 0.$$

The marginal social cost (i.e. the deadweight loss) of IPR protection in the South, denoted by MC$\equiv |\partial w_s/\partial T_s|$, increases with T_s:

$$\frac{\partial \mathrm{MC}}{\partial T_s} = N_s\frac{\partial M_n}{\partial T_s}[1-\alpha^{\alpha\epsilon}](1-\alpha)\alpha^{\alpha\epsilon} > 0.$$

On the other hand, using the zero profit condition for firm M_n, we have

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

the sum of which captures the social marginal benefit (MB) from raising T_s. It is easy to check that the marginal benefit is decreasing in T_s.

We can draw a figure, which is similar to Figure 1, and show that at the optimal Southern IPR protection, T_s^*, the MC curve and the MB curve intersect. Mathematically, T_s^* is determined by the first order condition, which is reduced to[9]

$$\mu^b(1-\alpha^{\alpha\epsilon}) = N_s A[T - T_s(1-\alpha^{\alpha\epsilon})](b\mu^{b-1}), \tag{3}$$

where

$$\text{LHS} = \frac{\text{MC}}{N_s(1-\alpha)\alpha^{\alpha\epsilon}}, \quad \text{RHS} = \frac{\text{MB}}{N_s(1-\alpha)\alpha^{\alpha\epsilon}}.$$

First, we check the constraints on the parameters. Using (3), we can show that with Constraint 1 in place, a sufficient condition for $T_s^* \le T$ is

Constraint 2: $1-(1+\alpha+c)\alpha^{\alpha\epsilon} > 0.$

It requires that c is small. The reason is similar to that for Constraint 1.

Again, by setting $T_s = 0$ in (3) and imposing LHS < RHS, we obtain the necessary and sufficient condition for $T_s^* > 0$, which is

$$N_s T b > N_n T_n^*[1-\alpha^{\alpha\epsilon}].$$

Thus, to have $T_s^* > 0$, we need

Constraint 3:

$$\frac{N_s}{N_n} > \frac{1-\alpha^{\alpha\epsilon}}{1-(1+\alpha+b)\alpha^{\alpha\epsilon}+b}.$$

The implication of Constraint 3 is that if the Southern market is not too small relative to the Northern market, the South has incentive to protect IPR.

We summarize the above analysis in Proposition 2 below.

Proposition 2 : *It is optimal for the South to protect IPR if and only if the Southern market is not too small compared with the Northern market.*

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

3 Analysis of the Optimal IPR Standards

In the preceding section, we have derived the conditions which determine the optimal Southern IPR protection given that $T_n = T_n^*$. In this section, we examine some properties of this optimal Southern protection and compare it with that in the North. First, we explore how T_s^* depends on the Northern IPR protection. To do this, we replace T_n^* in (3) by T_n which can take any value from 0 to T. Then, we have

Lemma 1 : *Suppose* $0 < T_s^* < T$*. Then, an increase in* T_n *leads to a strict decrease in* T_s^**, i.e.,* $\partial T_s^*/\partial T_n < 0$.

PROOF: From (3), it is obvious that $\frac{\partial LHS}{\partial T_s} > 0$, $\frac{\partial LHS}{\partial T_n} > 0$, $\frac{\partial RHS}{\partial T_s} < 0$, and $\frac{\partial RHS}{\partial T_n} < 0$. Therefore, an increase in T_n must be accompanied by a decrease in T_s to restore equality of the LHS and RHS. □

Therefore, stronger protection in the North makes it optimal for the South to protect less. The main reason for the substitution effect of Northern protection for Southern protection is that as T_n increases, the product variety is enlarged due to more incentive to innovate, and so the MC of protection in the South increases. This calls for a reduction of protection in the South, T_s. On the other hand, the MB of protection becomes smaller when consumers have obtained larger product variety, due to decreasing effect of variety on marginal benefit. That is, the MB in the South decreases. This also calls for lowering IPR protection in the South.

Next, we examine the implications of market size for optimal IPR protection.

Proposition 3 : *The optimal IPR protection in the South is longer if the Southern market becomes larger, or the Northern market becomes smaller. Mathematically,* $\partial T_s^*/\partial N_s > 0$ *and* $\partial T_s^*/\partial N_n < 0$.

PROOF: See Appendix A. □

It is interesting to understand why the two market sizes have the opposite impacts on the Southern IPR protection. The intuition behind $\partial T_s^*/\partial N_n < 0$ is the same as that for $\partial T_s^*/\partial T_n < 0$, which is given above. This is because a larger Northern market results in larger product variety, which increases the MC of protection while lowers the MB of protection. While a larger Southern market also leads to larger product variety, which therefore requires lowering the Southern IPR protection, more consumers in the South benefit from raising Southern IPR protection, increasing the MB of protection. This latter effect dominates the former one.

Finally, we obtain the last result of this section.

Proposition 4 : $T_s^* < T_n^*$. *That is, it is optimal for the South to protect IPR less than the North does.*

PROOF: See Appendix B. □

It is important to understand why the South has less incentive to protect IPR than the North. There are two reasons: the South takes into account the committed Northern IPR protection and trade opportunity when evaluating its optimal protection, and the South does not benefit from the additional profits accrued to Northern firms as T_s increases. Now we further explain why these two factors give rise to the result of Proposition 4. Recall that the ratio of the MC to MB of the northern IPR protection is equal to one at $T_n = T_n^*$, and now in regime 2, the MC to MB ratio of the Southern IPR protection is equal to one at $T_s = T_s^*$. Thus, T_s^* is smaller than T_n^* if and only if the ratio of MC to MB of IPR protection for the South is greater than one at $T_s = T_n^*$. The intuition for Proposition 4, therefore, comes from why the ratio is higher for the South than the North at the same level of protection. First, the fact that the South takes into account the committed Northern protection results in a higher MC to MB ratio. To see why, note that if the South adopts $T_s = T_n^*$ given that the Northern has already adopted the same standard, there would be more Northern innovations then expected by the North, which assumes that $T_s = 0$ and no trade. Thus, the product variety in the world is larger than that expected by the North. (Mathematically, this is the same as $\mu > m$.) Because of the increasing effect of variety on marginal cost of protection, the marginal cost of IPR protection is higher when the committed Northern protection is taken into account. On the other hand, since there is decreasing effect of variety on marginal benefit of IPR protection, the marginal benefit of protection decreases. Second, because the South does not benefit from the increased profits of Northern firms as T_s increases, the MC of the South increases further. Therefore, there is an increase in the MC to MB ratio of the South above one when $T_s = T_n^*$.

4 Southern IPR Standard and Global Welfare

In this section, we evaluate the globally optimal IPR standard of the South given that $T_n = T_n^*$. We also examine condition under which the world benefits from increasing Southern IPR standard from $T_s = 0$ to $T_s = T_n^*$.

Before doing the above, we first deduce the optimal world standard if the whole world has to adopt a unified IPR standard. It turns out that no formal mathematical derivation is needed for this purpose. We can imgaine that the whole world is a closed economy with market size $N_s + N_n$. Only Northern firms can innovate, since $c = 0$. Comparing this system with the autarkic Northern economy, the only difference is the market size. Since T_n^* is the optimal IPR standard for an autarkic North, and the standard is independent of market size, we conclude that the optimal unified world standard is T_n^*. Therefore, we have the following proposition:

Proposition 5 : *If the world has to adopt a unified IPR standard, the optimal one is T_n^*, given that $c = 0$.*

Next, we evaluate the South's best reponse given $T_n = T_n^*$. Based on the analysis of subsection 2.2, it is easily obtained that the Northern representative consumer's utility at time t is

$$u_n(t) = M_n(1-\alpha)\alpha^{2\alpha\epsilon} + I_n, \quad \text{for } \ t \leq T_n;$$

$$u_n(t) = M_n(1-\alpha)\alpha^{\alpha\epsilon} + I_n, \quad \text{for } \ t > T_n.$$

Thus, the Northern welfare in regime 2, denoted by $W_n(T_s)$ or $w_n(T_s, M_s, M_n)$, is defined and given as

$$W_n(T_s) = w_n(T_s, T_n^*, M_n) = N_n \int_0^{T_n^*} u_n(t)\mathrm{d}t + N_n \int_{T_n^*}^{T} u_n(t)\mathrm{d}t + \int_0^{M_n} \Pi_n(i)\mathrm{d}i$$

$$= N_n M_n (1-\alpha)\alpha^{\alpha\epsilon}[T - T_n^*(1-\alpha^{\alpha\epsilon})] + N_n T I_n + \frac{1}{1+b} M_n^{\frac{1+b}{b}}.$$

Recall that $M_n = \mu^b$ where $\mu = (N_s T_s + N_n + T_n)A$. Therefore, for all T_s,

$$\frac{\partial W_n}{\partial T_s} = N_n \frac{\partial M_n}{\partial T_s}(1-\alpha)\alpha^{\alpha\epsilon}[T - T_n^*(1-\alpha^{\alpha\epsilon})] + \mu^b \frac{\partial \mu}{\partial T_s} > 0. \tag{4}$$

Similarly, by assuming that the Northern protection T_n can also be changed, we can show $\partial W_s / \partial T_n > 0$. We immediately obtain the following result.

Lemma 2 : *The North (South) always benefits from stronger IPR protection in the South (North), regardless of the current degree of protection in the South and the North, i.e.,* $\partial W_n/\partial T_s > 0$ *and* $\partial W_s/\partial T_n > 0$.

The sources of benefit come from enlarging product variety in both countries ($\partial M_n/\partial T_s > 0$ and $\partial M_s/\partial T_n > 0$) and increasing innovators' profits ($\partial \Pi_n(i)/\partial T_s > 0$ and $\partial \Pi_s(i)/\partial T_n > 0$). A firm's profit increases as a result of IPR protection in the foreign country. There is, therefore, a positive cross-border externality of IPR protection. Since a country's individually optimal IPR protection does not take into account this positive externality, IPR is underprotected from the world's point of view if countries all adopt their individually optimal IPR standards.

We now turn to considering the impact of increasing South's IPR protection on global welfare. By definition, the global welfare is the sum of the two countries' welfare, $W(T_s) = W_n(T_s) + W_s(T_s)$. First, we can easily check that $W(T_s)$ is concave in T_s, i.e., $d^2W/dT_s^2 < 0$, for all T_s. Second, by (3) and (4), we have,

$$\frac{dW}{dT_s}|_{T_s=T_s^*} = \frac{dW_s}{dT_s}|_{T_s=T_s^*} + \frac{dW_n}{dT_s}|_{T_s=T_s^*} > 0. \tag{5}$$

That is, by slightly raising the Southern IPR protection from its individually optimal level, T_s^*, the global welfare increases. This is due to the positive externality of IPR protection indicated by Lemma 2. This result supports the argument of raising Southern IPR protection if it is currently optimal for the South to protect. The question is how far the Southern IPR protection should be raised in order to achieve the global welfare optimum.

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

$$\frac{dW}{dT_s} = -(1-\alpha)\alpha^{\alpha\epsilon}N_s\{\mu^b(1-\alpha^{\alpha\epsilon})\}$$

$$+A(1-\alpha)\alpha^{\alpha\epsilon}N_s b\mu^{b-1}\{N_s[T - T_s(1-\alpha^{\alpha\epsilon})] + N_n[T - T_n^*(1-\alpha^{\alpha\epsilon})]\} + N_s A\mu^b. \tag{6}$$

If $dW/dT_s \geq 0$ at $T_s = T_n^*$, then raising the Southern standard to the Northern standard will increase global welfare. Otherwise, the global welfare is maximized by allowing $T_s < T_n^*$. We show in Proposition 6 below that the former case never occurs. Let $T_s^w \equiv \text{argmax } W$, the Southern IPR protection which maximizes the global welfare.

Proposition 6 : *The global welfare is maximized when the IPR protection in the South is at a level below that of the North. Mathematically,*

$$\frac{dW}{dT_s}|_{T_s=T_n^*} < 0, \text{ which, together with (5), implies } T_s^* < T_s^w < T_n^*.$$

PROOF: See Appendix C. □

It is obvious that we just need to explain the inequality $T_s^w < T_n^*$. Recall from Proposition 1 that T_n^* is the optimal IPR protection for the North and it is chosen when the North does not trade with the South. When the IPR protection is chosen in a closed economy, there is no underprotection since there is no externality in IPR protection. The globally optimal IPR protection should internalize any cross-border externality arising from a country's IPR protection, just as the choice of T_n^* internalizes the all the externalities within a closed economy. Notice also that T_n^* does not depend on the market size. Therefore, if the South has the same innovative capability as the North, the optimal global IPR protection should be equal to T_n^*. On the other hand, T_n^* increases with b (by Proposition 1). This implies that $T_s^w < T_n^*$ since $b > 0$. The above discussion suggests that the value of T_s that maximizes global welfare is less than T_n^* because the innovation ability in the South is lower than that in the North.

Therefore, though T_n^* is the globally optimal unified world IPR protection standard, it is globally optimal for South to adopt an IPR standard lower than T_n^* given that the North is committed to that standard.

While it is globally optimal for the South to adopt a lower IPR standard than the North, the globally optimal Southern IPR standard gets higher as the South gets larger. This is proved in Proposition 7 below.

Proposition 7 : *The Southern level of IPR protection which maximizes global welfare is an increasing function of the size of the Southern market. Mathematically, we have* $\partial T_s^w / \partial N_s > 0$.

PROOF: See Appendix D. □

The Southern market size may affect the global optimal IPR protection in many ways, but the following is the most important one. We have now understood that the reason for

$T_s^w > T_s^*$ is that the former takes into account the positive cross-border externality of the Southern IPR protection, but the latter does not. As N_s increases, there will be more innovations and larger product variety, and therefore the magnitude of the positive externality of Southern IPR protection is larger. This calls for an increase in Southern IPR protection to internalize the externality.

Next, we evaluate the condition under which the world benefits from $T_s = 0$ to $T_s = T_n^*$. The conclusion based on numerical simulation using Mathematica is summarized below:

Proposition 8 : *(Numerical result) When the Southern market is sufficiently small, global welfare is lower forcing the South to adopt the Northern IPR standard than allowing the South to adopt its individually optimal IPR standard.*

For example, the simulation reveals that it is both optimal to the South and globally optimal for the South not to protect at all when N_s is sufficiently small compared with N_n.

Some argue that it might benefit the South for it to adopt the current Northern standard as South's innovative capability increases. Assume that T_n^*, the committed IPR standard of the North, would not be changed for a long time. Suppose c increases to a non-trivial level. We then evaluate the individually optimal as well as globally optimal level of Southern IPR protection and compare it with T_n^*. We found that Propositions 3 to 8 all continue to hold. The proofs are given in the appendix.

5 Summary and Conclusion

As far as we are aware of, our paper is one of the first on international intellectual property rights protection that endogenizes optimal level of IPR protection in each country. We assume that the South has no innovative capability and that it does not protect IPR at all before the TIPS agreement was signed. We interpret the TRIPS agreement as one that committed the world to the prevailing IPR standard of the North at the time the agreement was signed. Many interesting results are obtained. Some of them agree with the findings in the literature, but a richer set of results is obtained. A summary of our findings is given below:

As long as the Southern market is sufficiently large compared with that of the North, it is optimal for the South to protect IPR even if the South has no innovative capability at all.

However, it would never be optimal for the South to adopt an IPR standard as stringent as that of the North. This is because the South takes into account the committed Northern IPR protection and trade opportunity when evaluating its optimal protection, and the South does not benefit from the additional profits accrued to Northern firms as Southern IPR protection is strengthened.

If the world has to adopt a unified IPR standard, the globally optimal one is the pre-TRIPS Northern standard. However, given that the North is committed to its pre-TRIPS standard, it is globally optimal for the South to adopt an IPR standard below the Northern standard. This finding points to the shortfall of unifying the IPR standards of the world when the more innovative region has committed to an optimal IPR standard of its own.

There is a positive externality in strengthening a country's IPR protection under free trade, since the domestic country does not capture the increase in profits of the foreign firms resulting from the increased IPR protection. Therefore, when it is individually optimal for the South to protect IPR at all, it is globally optimal for the South to increase its IPR protection above its individually optimal level, at least to a certain extent. This contrasts with the result in Chin and Grossman (1990). Our result suggests that it would be mutually beneficial for the South to improve its existing level of protection, at least up to a certain point, provided that the North compensate the South sufficiently so as to leave the latter at least as well-off as before.

Although it might be globally optimal for the South to increase its IPR protection above its individually optimal level, it is globally optimal for the South to adopt a weaker IPR standard than that of the North. The main reason is that the South has lower capability to innovate than that of the North.

Under certain conditions (for example, when the Southern market is much smaller than that of the North), global welfare will be lower by forcing the South to adopt the Northern standard than allowing the South to adopt its individually optimal standard.

As the South gets larger, it is individually optimal for it to strengthen IPR protection. (Therefore, as China's market for patented goods grows, it should have more incentive to strengthen IPR protection.) Whereas Chin and Grossman find that it is optimal for the South to protect IPR when its market is sufficiently large, however, we find that it is optimal for the South to protect more when its market is larger, but the South never has the incentive to protect as strongly as the North does.

As the South gets larger (smaller), it is also globally optimal for it to strengthen (weaken) IPR protection. This result is somewhat consistent with the finding of Deardorff (1992), who finds that when the fraction of the world that is weak in IPR protection is large (small), it is globally optimal to increase (decrease) protection in the weakly protected countries. What cannot be addressed by Deardorff, but addressed by us, is that the globally optimal level of protection in the South would never be as high as that of the North, since the South has no or very low innovative capability compared with the North.

Appendix

A Proof of Proposition 3.

Define $R \equiv A[T - T_s(1-\alpha^{\alpha\epsilon})]b$ and $S \equiv (1-\alpha^{\alpha\epsilon})$. All of these expressions are independent of N_s. Recall that $\mu \equiv N_sT_s + N_nT_n$. Equation (3) can be rewritten as

$$RN_s\mu^{b-1} - S\mu^b = 0$$

It is straightforward to prove that $\frac{\partial}{\partial N_s}(RN_s\mu^{b-1} - S\mu^b) > 0$, and $(\frac{\partial}{\partial T_s}RN_s\mu^{b-1} - S\mu^b) < 0$. Therefore, $\frac{\partial T_s^*}{\partial N_s} > 0$.

Similarly, we can prove that $\frac{\partial}{\partial N_n}(RN_s\mu^{b-1} - S\mu^b) < 0$. Therefore, $\frac{\partial T_s^*}{\partial N_n} < 0$.

B Proof of Proposition 4.

The result obviously holds if $T_s^* = 0$. Otherwise, the optimal T_s^* is determined by equation (3). What we are going to show below is that $LHS_3 > RHS_3$ when $T_s = T_n^*$, and therefore the optimal T_s^* is less than T_n^* in order to restore equality of both sides of equation (3).

From (3),

$$\begin{aligned} LHS_3 &> (\mu^b)[1-(1+\alpha)\alpha^{\alpha\epsilon}] \\ &\quad \text{(since the increased profits of Northern firms resulted from} \\ &\quad \text{increased Southern protection do not increase Southern welfare)} \\ &= \frac{\mu}{b}\cdot(b\mu^{b-1})[1-(1+\alpha)\alpha^{\alpha\epsilon}] \end{aligned}$$

$$
\begin{aligned}
&> \frac{N_s}{N_n} \cdot (\frac{m}{b})(b\mu^{b-1})[1-(1+\alpha)\alpha^{\alpha\epsilon}] \qquad \text{since } \mu > m, \text{ and we impose } T_n^* = T_s \\
&= [T - T_n^*(1-\alpha^{\alpha\epsilon})]AN_n \cdot \frac{N_s}{N_n} \cdot (b\mu^{b-1}) \qquad \text{from (1)} \\
&= RHS_3.
\end{aligned}
$$

Therefore, $LHS_3 > RHS_3$ when $T_s = T_n^*$. That is, when the South protects as much as the North, it finds that the marginal cost of protection is greater than the marginal benefit of protection. So, it is optimal for the South to lower its IPR protection below that of the North. □

C Proof of Proposition 6.

Based on (6), we obtain

$$\frac{dW}{dT_s}|_{T_s=T_n^*} = -(1-\alpha)\alpha^{\alpha\epsilon}N_s(\Phi_4 + \Phi_5),$$

where $\Phi_4 = (\sigma AT_n^*)^c\{1-(1+\alpha)\alpha^{\alpha\epsilon} - c[T - T_n^*(1-\alpha^{\alpha\epsilon})]/T_n^*\}$, and $\Phi_5 = (\sigma AT_n^*)^b\{1-\alpha^{\alpha\epsilon} - b[T/T_n^* - (1-\alpha^{\epsilon})] - \alpha^{\epsilon}\}$. Substituting T_n^*, we can easily show $\Phi_5 = 0$ and

$$\Phi_4 = (\sigma AT_n^*)^c(1-\frac{c}{b})[1-(1+\alpha)\alpha^{\alpha\epsilon}] > 0, \;\; \text{since} \;\; b > c.$$

The result, $\frac{dW}{dT_s}|_{T_s=T_n^*} < 0$, follows. □

D Proof of Proposition 7.

By definition, T_s^w is the solution to the first order condition $\mathrm{d}W/\mathrm{d}T_s = 0$, where $\mathrm{d}W/\mathrm{d}T_s$ is given in (6). Differentiating this first order condition with respect to N_s and collecting terms will give

$$N_s\Phi_6\frac{\partial T_s^w}{\partial N_s} = \Phi_7,$$

where $\Phi_6 = \{c\mu^{c-1}[1-(1+\alpha)\alpha^{\alpha\epsilon}] + b\mu^{b-1}(1-\alpha^{\alpha\epsilon})\} + AN_s[c(1-c)\mu^{c-2} + b(1-b)\mu^{b-2}]\{N_s[T - T_s(1-\alpha^{\alpha\epsilon})] + N_n[T - T_n^*(1-\alpha^{\alpha\epsilon})]\} + (c\mu^{c-1} + b\mu^{b-1})N_s(1-\alpha^{\alpha\epsilon}) - \alpha^{\epsilon}b\mu^{b-1}$, which is positive because $b\mu^{b-1}(1-\alpha^{\alpha\epsilon}) - \alpha^{\epsilon}b\mu^{b-1} > 0$, and $\Phi_7 = \{N_s[T - T_s(1-\alpha^{\alpha\epsilon})] + N_n[T - T_n^*(1-\alpha^{\alpha\epsilon})]\}\{c\mu^{c-2}[\mu - AN_sT_s(1-c)] + b\mu^{b-2}[\mu - AN_sT_s(1-b)]\} + T_sc\mu^{c-1}\{N_s[T/T_s - (1-\alpha^{\alpha\epsilon})] - 1 + (1+\alpha)\alpha^{\alpha\epsilon}\} + T_sb\mu^{b-1}\{N_s[T/T_s - (1-\alpha^{\alpha\epsilon})] - 1 + \alpha^{\epsilon} + \alpha^{\alpha\epsilon}\}$, which is positive because all three terms are positive. The result, $\partial T_s^w/\partial N_s > 0$, follows. □

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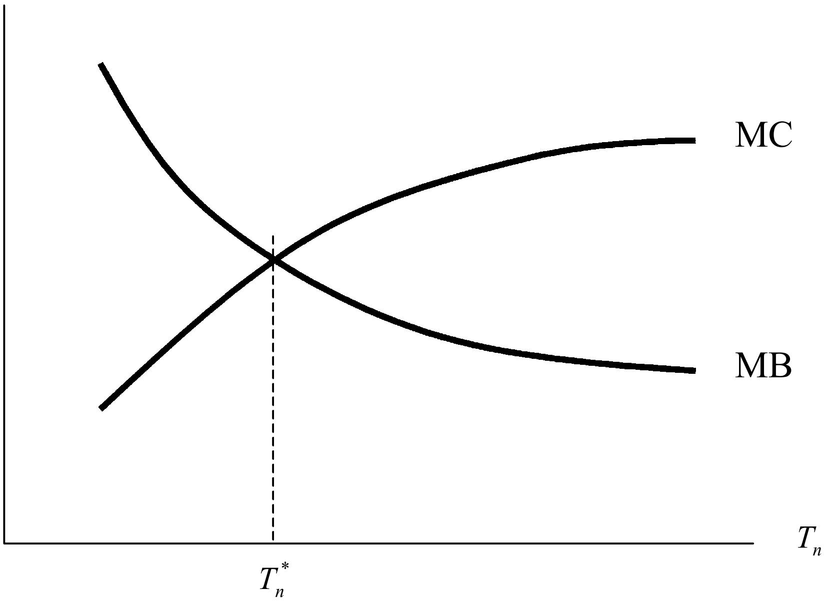

Figure 1. The determination of the optimal patent length in a closed economy.

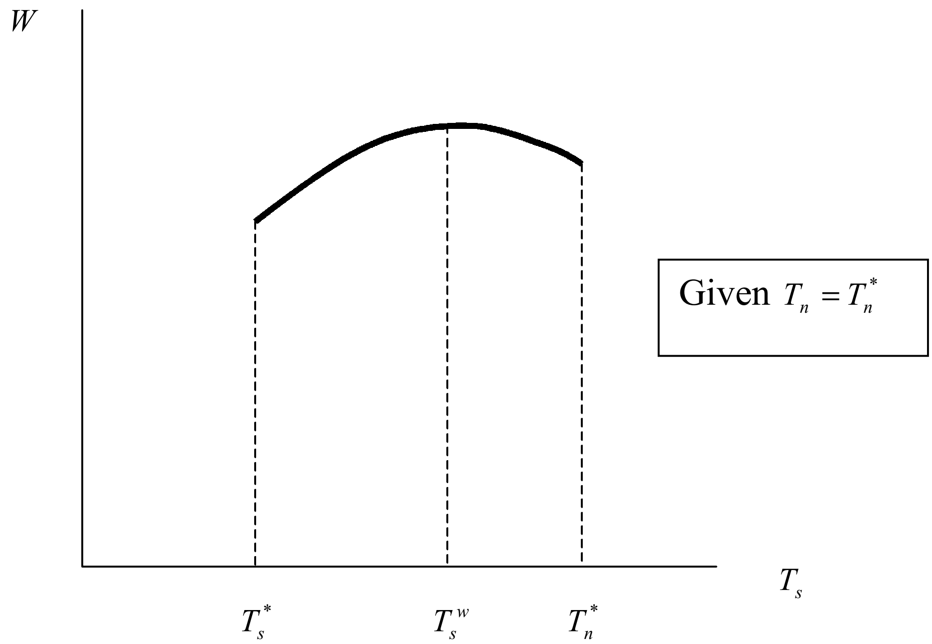

Figure 2. The variation of W with T_s.

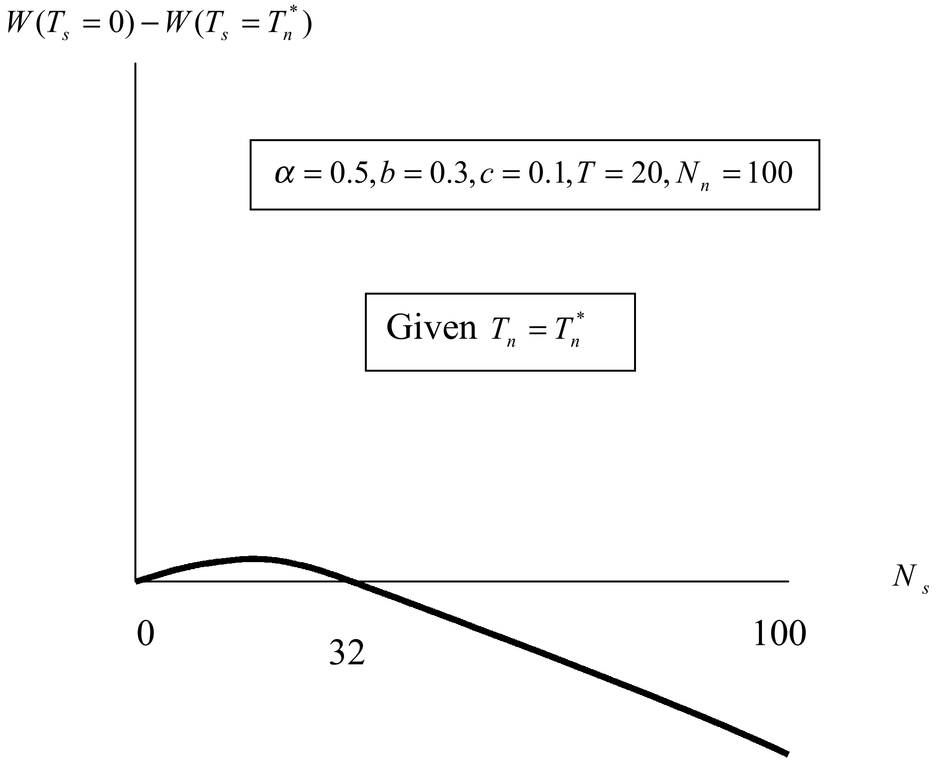

Figure 3. Effect of N_s on W when c is sufficiently small.

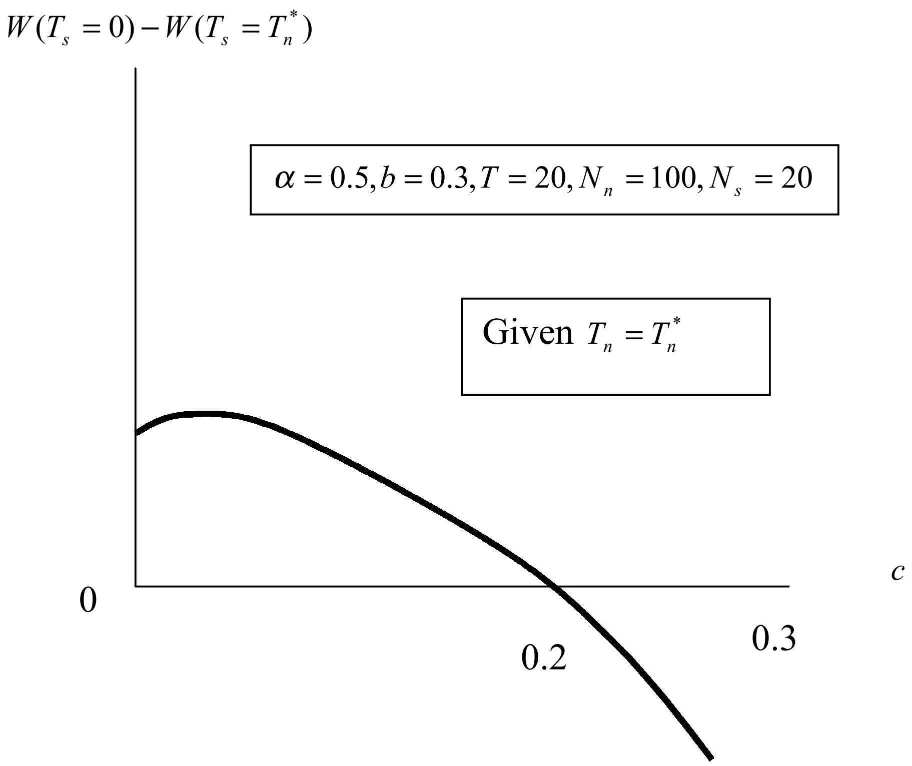

Figure 4. Effect of c on W when N_s is sufficiently small.

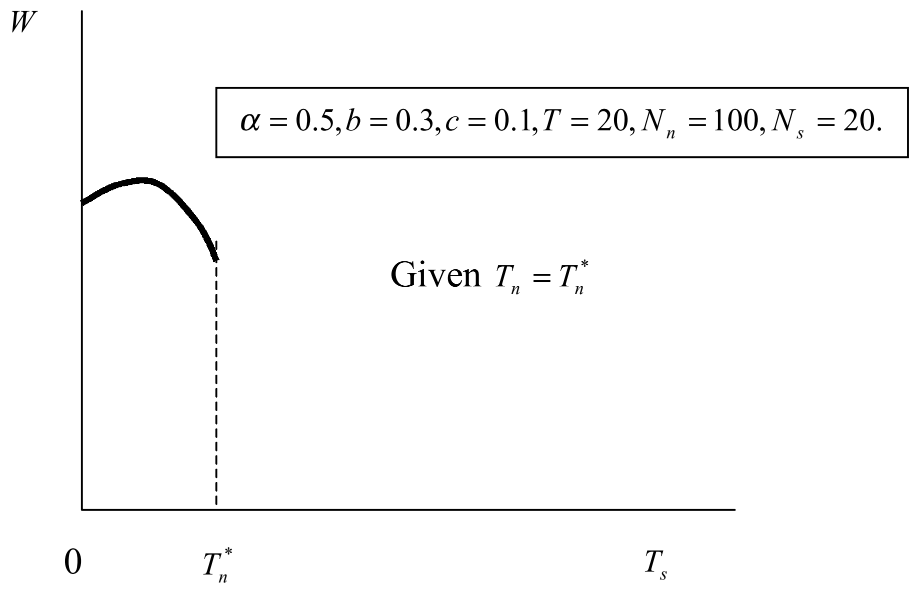

Figure 5A. $W(T_s = 0) > W(T_s = T_n^*)$ if c and N_s are sufficiently small, but in this case W is maximized when $T_n^* > T_s > 0$.

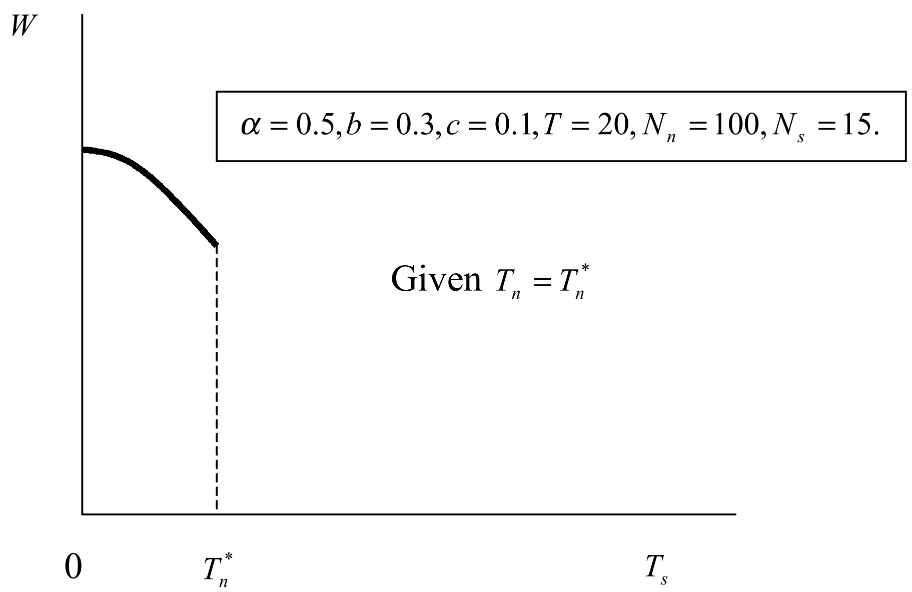

Figure 5B. In this case, global welfare is maximized when the South does not protect IPR at all, if c and N_s are sufficiently small.

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