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ABSTRACT

We study the incentive that a government in the South has to protect the intellectual property rights of Northern firms, and the consequences of the decision taken by the South for welfare in the North and for efficiency of the world equilibrium. We conduct our analysis in the context of a competition between a single Northern producer and a single Southern producer selling some good to an integrated world market. In this competition, only the Northern firm has the ability to conduct R&D in order to lower its production costs, but the Southern firm can imitate costlessly if patent protection for process innovations is not enforced by the government of the South. We find that the interests of the North and the South generally conflict in the matter of protection of intellectual property, with the South benefitting from the ability to pirate technology and the North harmed by such actions. A strong system of intellectual property rights may or may not enhance world efficiency.

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I. Introduction

The issue of intellectual property rights has become a contentious one indeed in recent trade relations between North and South. In the North, producers of new knowledge and ideas rely on protection in the forms of patents, copyrights and trademarks to enable them to appropriate some of the benefits from investment in research and development. The Northern governments have responded to pleas for assistance from their corporate sectors in the face of billions of dollars of lost revenue and profits from piracy and counterfeiting[1] by applying pressure on the South to provide greater enforcement of property rights and by pushing for new codes of international behavior.[2] At the urging of the United States, for example, the parties to the GATT established as one of the fourteen negotiating groups of the Uruguay Round one charged "to clarify GATT provisions and elaborate as appropriate new rules and disciplines regarding international enforcement of intellectual property rights" (Baldwin, 1988, p.65). The South, for its part, manifests almost total dependency on the North for the technologies needed for growth and development. These countries fear exploitation at the hands of innovative firms in the North in view of their weak bargaining position. They have been quite reluctant to accede to Northern demands for strengthening of standards on protection of intellectual property (GAO, 1987).

The welfare economics of intellectual property rights in a closed-economy setting are reasonably well understood. A fundamental tension exists between the social desirability of widespread dissemination of available know-how and the need for society to provide adequate rewards to purveyors of new information. The tension stems from the public-good nature of most forms of knowledge; once generated, knowledge can be used simultaneously by many parties besides the original creator at zero or minimal additional cost. This

consideration argues against protection of intellectual property, since the granting of property rights can only diminish the efficiency of use of a given knowledge base. But absent some form of protection, private agents will have little reason to invest their resources to generate new information and technologies. The socially optimal degree of protection of intellectual property requires a balancing of these fundamentally opposing objectives (see Nordhaus, 1969). Most governments have chosen to award limited market power (in the form of narrowly prescribed patents, copyrights and trademarks) to innovators as a compromise solution in which some static misallocation is accepted as the cost of preserving dynamic incentives.

In a world economy inhabited by sovereign governments, the issue of protection of intellectual property becomes all the more complex. The globally efficient degree of protection need not serve the separate interests of the individual governments that must enforce property rights. In particular, one would suspect that national well-being is maximized by a higher degree of protection of intellectual property in countries that develop new technologies and stand to earn monopoly rents from their application than in countries that only consume the goods and services that are produced using new ideas. But conflict of interest between governments is by no means inevitable. As an extreme example, suppose no product development would take place in an industry absent adequate protection against piracy and infringement. Then a country with no capability to conduct R&D would nonetheless benefit from enforcement of patent and copyright laws insofar as its consumers stand to capture some surplus from any new products marketed within its borders. Indeed the U.S. government, in its discussions with trade partner governments in the South, has sought to emphasize the stake that the latter

have in the intellectual property rights system (see GAO, 1987, pp.43-44).

In this paper, we study the welfare economics of patent protection in a North-South trading environment.[3] We suppose that initially a Northern firm and a Southern firm have access to an "old" technology to produce a good that is demanded in both countries. The Northern firm alone also has the ability to devote resources to an R&D project in order to improve the production technology. If foreign intellectual property rights are protected by the government in the South, then the Northern firm will gain via its R&D efforts a competitive advantage over its Southern rival. It can exploit this advantage in the ensuing international oligopolistic competition by capturing an increased share of the market, or, in some circumstances, by licensing its superior technology to its rival. If alternatively, the government in the South fails to enforce patent protection over the new production process, then the Southern firm will be able to pirate the innovative technology and can once again become an equal competitor in the international marketplace. This prospect, we assume, is well understood by the Northern firm, which then sets its R&D outlays accordingly.

We investigate the extent to which patent protection by the government of the South adds to social welfare in each country separately, and in the world as a whole. In our model, global patent protection serves to stimulate innovation, so that production costs are lower (for at least the Northern firm) in the sales-stage equilibrium. This effect alone acts to the benefit of both countries. Against this is the fact that enforcement of patent protection mitigates, and in some cases eliminates, oligopolistic competition, to the detriment of welfare in both countries. Finally, the presence or absence of protection of intellectual property in the South has implications

for the international distribution of income, as the Northern firm captures a greater share of extra-normal industry profits when rights are protected than it does when infringement takes place.

The remainder of our paper is organized as follows. In the next section we develop the model described above, and compare levels of welfare in each country with and without Southern protection for Northern intellectual property. We maintain the assumption, in this section, that international licensing arrangements between horizontal competitors are infeasible. In Section III, we introduce the possibility of licensing, ask when it will take place, and then re-examine the welfare comparisons of the protection and no-protection regimes. We discuss some implications of our analysis for current international economic relations in the concluding section.

II. Patent Protection When Licensing is Infeasible

We consider a linear-quadratic Cournot duopoly in an integrated world economy. Initially, one firm in the North and one firm in the South can produce some homogenous good at constant marginal cost, α. The Northern firm now faces an opportunity to devote resources to a deterministic R&D project in order to improve upon the existing production technology. The firm can achieve a <u>cost reduction</u> of amount Δ by spending Δ^2/γ on process innovation. Letting R denote its research outlay, its post-innovation marginal cost of production will be[4]

$$(1) \qquad C(R) = \alpha - (\gamma R)^{1/2} , \qquad R \leq \alpha^2/\gamma .$$

Final marginal cost in the South will depend upon whether or not the

Northern firm's patent rights to its innovative production process are protected by the government of the South, and on whether or not the Southern firm is able and willing to negotiate a licensing agreement with its Northern rival. We assume throughout this section that the complexity of the technology and the attendant difficulties in writing an enforceable contract preclude any licensing agreements. Then, if property rights are protected, the Southern firm's cost of production remains $c = \alpha$. If, alternatively, the government of the South fails to enforce the Northern firm's patent rights, the Southern firm will be able to imitate the innovative technology. To make our arguments as sharp as possible, we suppose that the cost of reverse engineering is negligible.[5] Then absent protection for intellectual property marginal production costs in the South are equal to those in the North.

After the Northern firm completes its R&D project and the Southern firm imitates if possible, the two firms engage in Cournot (quantity-setting) competition. We adopt a linear form for (inverse) demand in the integrated world market, and choose units so that this curve has a slope of one. Then

$$P = \beta - (y + Y), \qquad \beta > \alpha, \tag{2}$$

where P is the market-clearing price of the good and y and Y are the quantities sold by the Southern and Northern firms, respectively. We assume as well that at every price a constant fraction $1/\theta$ of demand originates in the marketplace of the South. This implies an inverse demand function in the South of $p(q) = \beta - \theta q$, where q is the quantity sold there, and also that the South will enjoy a fraction $1/\theta$ of total world consumer surplus at any equilibrium price.

A. Property Rights Violated

We begin by solving the model under the assumption that the government of the South fails to protect the intellectual property rights of the Northern firm. Then the ultimate market structure is one of symmetric duopoly with common costs C=c. These of course depend on the prior R&D decision of the Northern firm. As is well known, the Cournot equilibrium levels of output in this instance are $y = Y = (\beta-C)/3$ and the equilibrium price is $P = (\beta+2C)/3$.

We assume that, at the R&D phase, the Northern firm correctly foresees the implications of its actions for the subsequent product-market competition. That is, we seek a dynamic equilibrium that satisfies the sub-game-perfection constraint. The problem facing the Northern firm in the first stage of the game is to choose R to maximize total profits

$$(3) \qquad Z(R) = \frac{\left[\beta - \alpha + (\gamma R)^{1/2}\right]^2}{9} - R \ ,$$

where the expression for operating profits in (3) represents the product of price and per-unit profit. The first-order condition for a profit maximum implies[6]

$$(4) \qquad R = \frac{\gamma(\beta-\alpha)^2}{(9-\gamma)^2}$$

from whence we derive profits for each firm:

$$(5n) \qquad Z = \frac{(\beta-\alpha)^2}{9-\gamma} \ ;$$

$$(5s) \qquad z = \frac{9(\beta-\alpha)^2}{(9-\gamma)^2} \ .$$

Consumer surplus, S and s, in each country is the area between the inverse demand curve and the equilibrium price line. Straightforward calculations reveal

$$(6n) \qquad S = 18 \frac{\theta-1}{\theta} \frac{(\beta-\alpha)^2}{(9-\gamma)^2} ,$$

$$(6s) \qquad s = \frac{18}{\theta} \frac{(\beta-\alpha)^2}{(9-\gamma)^2} .$$

Finally, total surplus in each country, W and w, is the sum of consumer surplus and producer surplus, or

$$(7n) \qquad W = \left[9 - \gamma + 18 \frac{\theta-1}{\theta} \right] \frac{(\beta-\alpha)^2}{(9-\gamma)^2}$$

$$(7s) \qquad w = 9 \left(\frac{\theta+2}{\theta}\right) \frac{(\beta-\alpha)^2}{(9-\gamma)^2} .$$

B. Property Rights Protected

If the government of the South does indeed prevent its local firm from infringing upon the patent rights of the Northern innovator, then the duopolists bear different marginal costs at the time that they meet in the product market. In this case, three types of equilibria may arise, depending upon the size of the parameter γ describing the effectiveness of R&D in reducing production costs. For small values of γ the R&D efforts of the Northern firm will be modest, and asymmetric duopoly will characterize the final stage of competition. For large values of γ the Northern firm will find

it optimal to reduce its costs substantially, so much so that it will enjoy an unfettered monopoly position in the product market. Finally, when γ takes on intermediate values, the Northern firm will act strategically to induce exit by its rival (see Dixit, 1980). Then its final position in the product market will be one of monopoly, but the firm will find itself constrained to choose a level of R&D spending sufficiently large to guarantee non-positive profits for its rival. We shall refer to this last market structure as one of strategic predation. We proceed now to find optimal levels of R&D, and equilibrium profits, consumer surplus, and total welfare for each of these scenarios, and to delimit the values of γ for which each applies.

Consider first the output stage of an asymmetric duopoly with costs C and c. The two first-order conditions equating perceived marginal revenues to marginal costs imply a Cournot equilibrium with $Y = (\beta - 2C + c)/3$ and $y = (\beta - 2c + C)/3$, and an associated equilibrium price $P = (\beta + C + c)/3$. Anticipating these outcomes, the Northern firm chooses R to maximize

$$(8) \qquad Z(R) = \tfrac{1}{9}\left[\beta - \alpha + 2\gamma^{1/2}R^{1/2}\right]^2 - R$$

The optimal choice of R when duopolistic competition is foreseen satisfies

$$(9) \qquad R = \frac{4\gamma(\beta-\alpha)^2}{(9-4\gamma)^2} .$$

But, with this level of R&D, output by the Southern firm remains positive if and only if $\gamma < 3/2$. So, $\gamma < 3/2$ is necessary for the duopoly outcome to obtain.

If duopoly does obtain, the expressions for equilibrium outputs and price

imply

$$(10n) \qquad Z = \frac{(\beta-\alpha)^2}{9-4\gamma}$$

and

$$(10s) \qquad z = \frac{(3-2\gamma)^2(\beta-\alpha)^2}{(9-4\gamma)^2} \quad .$$

We can also calculate levels of consumer surplus, whence we find

$$(11n) \qquad S = \frac{2(\theta-1)}{\theta} \frac{(\beta-\alpha)^2(3-\gamma)^2}{(9-4\gamma)^2} \quad ;$$

$$(11s) \qquad s = \frac{2}{\theta} \frac{(\beta-\alpha)^2(3-\gamma)^2}{(9-4\gamma)^2} \quad .$$

Summing the respective consumer and producer surpluses for each country gives

$$(12n) \qquad W = \frac{(\beta-\alpha)^2}{(9-4\gamma)^2} \left[9 - 4\gamma + \frac{2(\theta-1)}{\theta}(3-\gamma)^2 \right] \quad ;$$

$$(12s) \qquad w = \frac{(\beta-\alpha)^2}{\theta(9-4\gamma)^2} \left[\theta(3-2\gamma)^2 + 2(3-\gamma)^2 \right] \quad .$$

Now suppose, for the moment, that the Northern firm were to face no competition whatsoever. Then its jointly optimal choices of output and research would be $Y = 2(\beta-\alpha)/(4-\gamma)$ and $R = \gamma(\beta-\alpha)^2/(4-\gamma)^2$. When would these choices represent an equilibrium despite potential competition from the firm in the South? If, at the implied monopoly price $P = [\beta(2+\gamma)+2\alpha]/(4-\gamma)$ the

Southern firm could not cover its production cost α, then the rival would choose to exit the industry. From this, we see that unconstrained monopoly results whenever $\gamma > 2$.[7] In this case,

$$(13n) \qquad Z = \frac{(\beta-\alpha)^2}{4-\gamma} \quad ,$$

$$(14n) \qquad S = \frac{2(\theta-1)}{\theta} \frac{(\beta-\alpha)^2}{(4-\gamma)^2} \quad ,$$

$$(15n) \qquad W = \frac{(\beta-\alpha)^2}{\theta(4-\gamma)^2} (6\theta - \gamma\theta - 2) \quad ,$$

while $z = 0$ and

$$(14s) \qquad w = s = \frac{2(\beta-\alpha)^2}{\theta(4-\gamma)^2} \quad .$$

Finally, for values of $\gamma \in [3/2,2]$, the monopoly choice of research spending invites competition from the Southern rival, whereas the optimal choice of R&D from (9) more than suffices to guarantee the rival's exit from the market. For these intermediate values of γ the Northern firm conducts just enough R&D to guarantee $y = 0$; i.e., it drives its own cost to $2\alpha-\beta$ and the price to α. This requires a research outlay of $R = (\beta-\alpha)^2/\gamma$ and yields profits equal to

$$(16n) \qquad Z = \frac{(\theta-1)}{\theta}(\beta-\alpha)^2 \quad .$$

Then consumer surplus and total welfare in the North are given by

(17n) $S = \frac{\theta-1}{2\theta}(\beta-\alpha)^2$;

(18n) $W = (\beta-\alpha)^2\left(\frac{\gamma-1}{\gamma} + \frac{\theta-1}{2\theta}\right)$.

In the South, we have, in this case, $z = 0$ and

(17s) $w = s = \frac{(\beta-\alpha)^2}{2\theta}$.

It is a simple matter to check that, for all $\gamma < 3/2$, Northern profits from (10n) exceed those from (16n), so that $\gamma < 3/2$ is both necessary and sufficient for the duopoly outcome to obtain. Strategic predation occurs only for values of $\gamma \in [3/2,2]$.

C. Welfare Comparisons

We are now prepared to compare levels of welfare in each country and for the world as a whole across regimes when the government of the South does and does not protect the intellectual property rights of the Northern firm. We begin with the South. For $\gamma < 3/2$, the relevant welfare expressions are those in (7s) and (12s). Subtracting one from the other, we find

(19s) $\operatorname{sgn}\{w^{NP} - w^{P}\} = \operatorname{sgn}\{-486\theta + 405\theta\gamma + 108\gamma - 84\theta\gamma^2 - 48\gamma^2 + 4\theta\gamma^3 + 2\gamma^3\}$, $\gamma \in (0,3/2)$,

where superscripts "NP" and "P" have been used to indicate the regimes without protection of property rights and with protection, respectively. In general, the expression in (19s) is of ambiguous sign. But the right-hand side of

(19s) is positive when $\theta = 9/8$ for all $\gamma \in (0,3/2)$ and the right-hand side is increasing in θ for all γ in this range. From this we conclude that the South achieves higher national welfare when it neglects to protect intellectual property rights if a duopoly outcome will result under protection and if its share in world consumption does not exceed 88 percent.

Next consider the range of parameter values for which strategic predation is the outcome under patent protection. We subtract (14s) from (7s) to find

$$(20s) \qquad \text{sgn}\{w^{NP} - w^{P}\} = \text{sgn}\{18(\theta+2) - (9-\gamma)^2\}, \qquad \gamma \in [3/2,2] .$$

The expression on the right-hand side of (20s) also is positive for all $\theta > 9/8$ and also increases with θ. Hence, when strategic predation will occur under protection, a Southern consumption share of less than 88 percent is sufficient for the South to prefer non-protection.

Finally, we consider the range of parameter values for which the North would capture a monopoly position if its property rights were respected. Recall that this case arises when R&D productivity is especially high. The relevant welfare expressions are (7s) and (17s), and we find

$$(21s) \qquad \text{sgn}\{w^{NP} - w^{P}\} = \text{sgn}\{9\theta(\gamma-4)^2 + 2(8\gamma^2-54\gamma+63)\}, \qquad \gamma \in [2,4] .$$

For γ near 2, this expression remains positive unless the consumption share of the South is very high. But for γ large (near 4), the expression is <u>negative</u> for all $\theta > 1$. Thus, we find that protection of foreign intellectual property can benefit the South, but only when R&D is highly productive and the country stands to gain much on the consumption side from the fruits of the Northern

firm's research efforts.

In Figure 1, we have plotted the full range of permissible parameter values for γ and $1/\theta$. In the figure, we show the combinations of parameter values for which protection and non-protection best serve the selfish interests of the South. We see from the figure that the South will generally prefer to "look the other way" when patent infringement occurs, except in cases where its consumers absorb much of the world's output of the good subject to cost reduction or when the cost savings to be reaped from innovation are quite dramatic.

What then are the interests of the North? When we compare Northern welfare levels under protection and no-protection we find that, no matter what the value of γ and hence the market structure that would prevail with protection, the North <u>always</u> benefits form having its firm's property rights respected in the South.[8] Evidently, the consumption gain from increased competition can never outweigh the profit-distribution effect and the R&D-incentive effect. We conclude that conflict of interest between the North and the South in regard to the system of intellectual property rights is the rule rather than the exception in our model.

When international conflict exists, it is natural to ask whether there are potential gains from cooperation. In the present context we might wonder whether the North could bribe the South to enforce patent protection in cases where protection was not in the narrowly-defined self interest of the latter. A world system of protected intellectual property rights would result from <u>efficient bargaining with compensation</u>, for example, if the North's gains from enforcement exceeded the South's losses. To investigate this issue, we define world welfare, $\Omega = W + w$, and compare levels of Ω across regimes.

Suppose first that available productivity gains from R&D are modest; i.e., $\gamma < 3/2$. We have in this case

$$(19w) \qquad \text{sgn}\,(\Omega^{NP} - \Omega^{P}) = \text{sgn}\,(81 - 126\gamma + 40\gamma^2 - 2\gamma^3)\,, \qquad \gamma \in (0,3/2)\,.$$

The expression on the right-hand side of (19w) is positive in the relevant range for all $\gamma \leq .875$ and is negative for all $\gamma \geq .876$. Thus, protection of foreign intellectual property rights in the South indeed advances global efficiency if the prospects for productivity gain through R&D are sufficiently bright, but for modest potential advances in knowledge world welfare actually is higher when the South <u>fails</u> to enforce patent protection. Evidently, for small innovations, the benefit from the increased competition that results when diffusion takes place outweighs the cost in terms of dampened incentives for R&D investment.

For larger values of γ such that the Southern firm would exit the market absent the ability to infringe upon the Northern firm's patent, protection by the South of intellectual property rights always enhances global efficiency. Straightforward computation reveals that $\Omega^{P} > \Omega^{NP}$ for $\gamma > 3/2$. Our analysis suggests, therefore, that intellectual property rights ought to be strongly protected in highly innovative industries, but that the argument for protection is less compelling when technological advances are likely to be small.

III. <u>Patent Protection With Potential Licensing</u>

Until this point, we have excluded the possibility that, after the conclusion of its R&D project, the Northern firm might elect to license its superior technology to its rival in the South. We justified this exclusion

with reference to the costliness of writing enforceable contracts in some situations. But obviously there are circumstances where contracting considerations do not rule out licensing. Katz and Shapiro (1985) have studied the incentives for the sharing of technologies among horizontal competitors in such circumstances. We now adopt their approach to introduce the potential for licensing into our model, and then re-examine the international issues at hand.

A. Licensing Equilibria

As in Katz and Shapiro (1985), we suppose that licensing contracts can only be signed after research and development has been completed. It seems likely that if, instead, contracts were to be negotiated at some prior stage, and if they called for the sharing of (some amount of) information which at the time was not yet available to either party, then the resulting contracts would be extremely difficult to enforce. We add a third (licensing) stage to our game, one that takes place before the sales competition but subsequent to the commitment of R by the Northern firm. We also rule out, with reference to the antitrust laws applicable in most countries, any contracts that limit competition at the sales stage. We limit attention to contracts calling for a fixed licencing fee.[9]

When licensing agreements must be reached after R&D has been completed and imitation is costless, no agreements are possible in the absence of patent protection in the South. The Southern firm would never be willing to pay a positive fee to use the Northern firm's technology if it were possible for the firm to copy that technology at no cost. So, in this sub-section, we limit attention to situations where the South provides protection for intellectual property. We re-introduce the alternative possibility of no protection only

when we are ready to perform the regime comparisons.

The licensing of technology between horizontal competitors requires: (i) the existence of joint gains from sharing; and (ii) the resolution of a bilateral bargaining problem. Given the existence of potential gains, licensing might not take place if the two parties to the negotiation had asymmetric information about their separate interests and attributes. Since we have nothing to add to the voluminous literature on bargaining, we choose the simplest possible specification of this aspect of the model. We suppose that licensing will take place under patent protection whenever the joint profits of the two firms with licensing exceeds joint profits in the absence of licensing. We assume, moreover, that the Northern firm captures a fraction σ of the gains from trade, and treat σ as an exogenous parameter throughout our analysis.

More formally, let $\tilde{Z}(R)$ and $\tilde{z}(R)$ be the levels of profits that the Northern and Southern firms would obtain in the absence of any licensing agreement, and let $Z(R)$ and $z(R)$ be profit levels (not including any licensing fee) if technology sharing takes place. Then we assume that licensing will occur subsequent to a research effort at intensity R if and only if $Z(R)+z(R) \geq \tilde{Z}(R)+\tilde{z}(R)$, and that in such cases the Southern firm pays a fee

$$F(R) = \tilde{Z}(R) - Z(R) + \sigma[Z(R)+z(R)-\tilde{Z}(R)-\tilde{z}(R)] \tag{22}$$

for the right to use the Northern firm's superior technology. With this fee, the Northern firm's total profits, $Z(R) + F(R)$, are the sum of hypothetical profits in the absence of an agreement, $\tilde{Z}(R)$, and that firm's share σ of the gains from trade.

Katz and Shapiro (1985) have proven that, in models such as this one, licensing will not take place if the potential licensor would enjoy a monopoly position in the product market were it to exclude its rival from the superior technology. For this reason, we restrict our search for licensing equilibria to values of R such that asymmetric duopoly would be the outcome absent any agreement. For these values of R, the relevant expressions for $\dot{Z}(R)$ and $\dot{z}(R)$ are those that would arise in an asymmetric Cournot equilibrium with respective costs $C = \alpha - (\gamma R)^{1/2}$ and $c = \alpha$, while $Z(R)$ and $z(R)$ are those that arise in a symmetric Cournot equilibrium with costs $C = c = \alpha - (\gamma R)^{1/2}$. Inserting the appropriate terms in (22), we derive

$$(23) \qquad F(R) = \frac{(2+2\sigma)(\beta-\alpha)\gamma^{1/2}R^{1/2} + (3-3\sigma)\gamma R}{9} \quad .$$

Assuming that licensing will take place, the optimal choice of R for the Northern firm is the one that maximizes $Z(R) + F(R)$. The first-order condition for this problem yields

$$(24) \qquad R = \frac{\gamma(2+\sigma)^2(\beta-\alpha)^2}{[9+(3\sigma-4)\gamma]^2} \quad ,$$

with maximal cum-licensing profits (including the fee) equal to

$$(25n) \qquad Z + F = \frac{(\beta-\alpha)^2}{9[9+(3\sigma-4)\gamma]^2} \times$$

$$[81 + 9\gamma(\sigma^2+10\sigma-4) + \gamma^2(3\sigma^3+17\sigma^2-28\sigma)] \quad .$$

There remains the question of whether the Northern firm will select a value of R that yields licensing in the post-R&D licensing equilibrium as part of its globally optimal strategy. The firm could instead choose a higher level of R&D such that no licensing agreement would be reached once the research phase had been completed. The profits it could earn by doing so never exceed those given in (10n), corresponding to maximal profits in an asymmetric duopoly situation without licensing. In making its choice of R, the Northern firm compares the right-hand sides of (10n) and (25n). This comparison yields a critical value of γ as a function of σ, $\gamma^* = G(\sigma)$ with $G' > 0$, such that licensing takes place in equilibrium if and only if $\gamma < \gamma^*$. Examining this function, we find that when $\gamma > 1.406$ licensing never takes place (i.e., no matter what the value of σ), whereas if $\gamma < 1.285$ licensing always will occur with protection. For values of γ between 1.285 and 1.406, licensing is more likely to result the larger is σ.[10]

For values of γ such that licensing would not take place in the sub-game perfect equilibrium, the analysis of intellectual property rights is exactly as in Section II. So we restrict our attention here to those cases where, in the presence of patent protection, a licensing agreement would be reached. These cases are of special interest, because they imply that international technology transfer takes place in any event, either by commercial arrangement if patent protection is provided by the government of the South, or by piracy if not.

Using (24) and our formulae for Cournot equilibrium outputs and prices, we can calculate profits for the Southern firm and consumer surplus levels in each country in a licensing equilibrium. We find:

$$(25s) \qquad z - F = \frac{(\beta-\alpha)^2}{9(9-(4-3\sigma)\gamma)^2}\left[81 - 18\gamma(\sigma^2-\sigma+4) - \gamma^2(3\sigma^3-15\sigma^2+4\sigma-8)\right] ;$$

$$(26n) \qquad S = \frac{(\beta-\alpha)^2(\theta-1)}{9\theta(9-(4-3\sigma)\gamma)^2}\left[162 - 72\gamma(2\sigma-1) + 8\gamma^2(4\sigma^2-4\sigma+1)\right] ;$$

$$(26s) \qquad s = \frac{(\beta-\alpha)^2}{9\theta(9-(4-3\sigma)\gamma)^2}\left[162 - 72\gamma(2\sigma-1) + 8\gamma^2(4\sigma^2-4\sigma+1)\right] .$$

We calculate total welfare in each country, as before, by summing the consumer and producer surplus measures in (25) and (26).

B. Welfare Comparisons

We now are prepared to compare levels of welfare achieved under protection of foreign intellectual property in the South with those that arise when no protection is provided, in situations where protection gives rise to an equilibrium with international licensing of the new technology. This analysis involves comparison of (7i) with the sum of (25i) and (26i), for i=s,n. Since the general expressions are quite complicated and provide limited intuition, we proceed by focusing on several special cases.

The first case that we consider arises when σ=1. In this case, the Northern firm enjoys all the bargaining power in the licensing negotiations and extracts all the surplus from any agreement. We find

$$(27s) \qquad \text{sgn}\{w^{NP} - w^{P}\} = \text{sgn}\{\theta(2\gamma-9) + \gamma + 9\} .$$

In Figure 2, we show the combinations of γ and $1/\theta$ for which the right-hand side of (27s) is positive, and those for which it is negative. We see that

the South may benefit from protection of Northern intellectual property rights, but only if its share in world consumption of the good is quite high. A sufficient condition for non-protection to be the optimal strategy when σ=1 is $1/\theta < .59$.

From the point of view of the North, we have

$$\text{(27n)} \qquad \text{sgn}\,(W^{NP} - W^{P}) = \text{sgn}\,(\gamma + 9 - 16\theta)$$

For $\gamma < 1.406$ (the largest value of γ for which licensing takes place when σ=1), the right-hand side of (27n) always is negative. So we find again that the North benefits from having its intellectual property rights protected in the South.

Next we consider the opposite extreme case where bargaining power resides entirely with the firm in the South; i.e., σ=0. When σ=0 the South is more likely to benefit from protecting Northern property rights than it is when σ=1, and does so whenever its consumption share exceeds one-half (see Figure 3). However, when the consumption share of the South is not large (e.g., less than .4), the South still prefers to pirate Northern technology than to enter into a licensing agreement in which its firm will capture all of the surplus. This somewhat surprising result stems from the fact that the licensing fee remains strictly positive even when σ=0, and also from the differing incentives that the Northern firm has to carry out R&D in the two situations.

Comparing welfare levels for the North, for the case when its firm's bargaining power in the licensing negotiation is nil, we find that, for all permissible values of σ ($\leq$1) and γ ($\in (0,9/7)$), $W^{P} > W^{NP}$. Even if the Northern firm captures <u>none</u> of the surplus from any licensing agreement that

materializes between itself and its Southern rival, nonetheless the North enjoys greater welfare when its intellectual property rights are protected by the South.

Lastly, we consider an intermediate case where the gains from trade in knowledge are shared equally between the two rivals; i.e., $\sigma = 1/2$. Figure 4 depicts the parameter values for which the South prefers protection. The figure provides the same general message as for the more extreme cases, inasmuch as the South benefits from protection only when its residents absorb a large share of world output of the good. The critical values for $1/\theta$ at which protection becomes preferable lie between those of the earlier cases with σ=0 and σ=1. Also, we find as before that the North can only be harmed by a failure of the government of the South to protect its patent rights.

Our last inquiry concerns the implications of intellectual property rights for world welfare when protection induces a licensing agreement. Allowing once again for an arbitrary value of σ, we obtain

$$(29) \qquad \text{sgn}\,(\Omega^{NP} - \Omega^{P}) = \text{sgn}\,\{-729(5-\sigma)(1+\sigma) + 486\gamma(1-\sigma)(2+5\sigma) + 108\gamma^2(1-2\sigma)(3-5\sigma) - 16\gamma^3(1-2\sigma)^2\}$$

The expression on the right-hand side of (29) always is negative for $\sigma \in [0,1]$ and γ in the range where licensing obtains. Thus, contrary to our findings in Section II where licensing was considered to be infeasible, we find now that protection of intellectual property rights <u>always</u> enhances global efficiency when trade in technology can take place. Patent protection with licensing allows the world to enjoy both widespread dissemination of knowledge and the benefits of more intense product-market competition, while avoiding the

disincentive effects that plague a weak system of intellectual property-rights where infringement on patents is pervasive.

IV. Conclusions

In this paper we have studied the incentive that a government in the South has to protect the intellectual property rights of Northern firms, and the consequences of the decision taken by the South for welfare in the North and for efficiency of the world equilibrium. We have conducted our partial equilibrium analysis in the context of a competition between a single Northern producer and a single Southern producer selling some good to an integrated world market. In this competition, only the Northern firm has the ability to conduct R&D in order to lower its production costs, but the Southern firm can imitate costlessly if patent protection for process innovations is not enforced by the government of the South.

We found that, contrary to the commonly-voiced polemic of the U.S. government, the interests of the North and South generally conflict in this matter of international economic relations. Unless the South comprises a majority share of the market for the good whose technology is subject to improvement or the prospects for cost-savings through R&D are quite substantial, social welfare in the South will be higher when it eschews protection of foreign intellectual property than when it succumbs to pressure from the North. The North, on the other hand, always benefits from having the patents of its firm respected outside its borders. Surprisingly, perhaps, the global comparison can go either way; protection of intellectual property rights enhances world efficiency when productivity in R&D is great, but not when innovations are likely to be small. What is at stake here is the

familiar conflict between the benefits of widespread diffusion of technology and the increased competition that such diffusion entails, and the costs of dampened incentives to generate technological breakthroughs.

Needless to say, our results hinge on the special assumptions we have introduced. Most important, we feel, are our restriction to situations of duopoly and our exclusion of any possibility of innovation in the South. With more Southern firms and some scope for technological improvement there (including improvements that only serve to move the country closer to the world technological frontier), a strong system of protection for intellectual property may be necessary to prevent the Southern firms from appropriating technologies from each other. Yet some countries have been known to afford unequal treatment to foreigners in patent enforcement procedures (see ITC, 1988, p. 3.7). So protection of domestic and foreign property need not always go hand in hand, the provisions of the Paris Convention for the Protection of Industrial Property notwithstanding.

Our findings may contain an important lesson for negotiators in the Uruguay Round. Until now, the industrial countries have maintained the posture that governments in the South ought to respect Northern claims for property rights over knowledge and technology partly as a matter of moral principle and partly in their own self interest. If, as our analysis suggests, the South benefits by "borrowing" freely from the technologies produced in the North, then it may be more productive for the Northern governments to abandon this high moral position and treat the issue of intellectual property as they would any other one of conflicting national interests. In particular, if protection of intellectual property does indeed enhance <u>global</u> efficiency, as our analysis shows to be the case at least for

substantial innovations, then the North ought to be willing and able to compensate the South for any losses that it would incur in the course of providing such protection. The format of the GATT negotiations presumably presents an ideal opportunity for effecting such compensation, as Southern concessions on this issue might readily be exchanged for Northern concessions on some others (greater market access for Southern exports?).

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Endnotes

1. Responding to a survey conducted by the International Trade Commission (1988), 101 U.S. corporations cited lost export sales in 1986 due to inadequate foreign protection of intellectual property of $6.16 billion. Sixty-four respondents claimed lost sales in the United States totaling $1.80 billion. An additional $3.11 billion of lost royalty payments was noted by 104 respondents to the ITC survey. The ITC estimates that, for the companies in its sample, sales of infringing goods may have represented an average profit reduction of 10 percent in 1986. The International Anti-Counterfeiting Coalition estimates total annual losses of domestic and foreign sales by U.S. firms due to inadequate protection of intellectual property of approximately $20 billion (see Benko, 1987).

2. Further to its survey of U.S. corporations, the ITC (1988) reports that 122 companies cited fifty-four countries as having inadequate protection of patent rights for foreigners, while eighty-four respondents cited fifty-two countries as providing insufficient protection for copyrights. The countries most commonly cited in this regard are Mexico, Taiwan, Brazil and Korea. For discussion of the alleged inadequacies of foreign protection of U.S. intellectual property, see ITC (1988, Ch.3).

3. For an analysis of issues arising from foreign counterfeiting of domestic trademarks, see Grossman and Shapiro (1988a, 1988b).

4. We use an uppercase Roman letter to denote a variable relating to the North and the corresponding lowercase letter for the analogous variable for the South. Greek letters are reserved for parameters.

5. For an analysis of a (closed-economy) R&D game with costly imitation, see Katz and Shapiro (1987).

6. We assume in all cases that α is sufficiently large so that the non-negativity constraint on c does not bind.

7. We restrict attention to $\gamma < 4$, so that R&D remains finite at the monopoly optimum.

8. We compare (7n) with (12n), (17n), and (15n), for values of γ that give rise to duopoly, strategic predation and monopoly, respectively. In each case it is possible to show that $W^P - W^{NP} > 0$ at $\theta=1$, and that the derivative of this difference with respect to θ is positive for all γ in the relevant range.

9. As Katz and Shapiro discuss, the firms will prefer to negotiate contracts calling for royalties on a per-unit output basis, because such provisions can be used to enforce collusive arrangements in the product market. However, these types of contracts might be difficult to monitor and enforce, and might also bring the firms into conflict with the antitrust authorities.

10. These findings accord with the more general results reported in Katz and Shapiro (1985). They show for general demand functions and an arbitrary form of static, oligopolistic competition (satisfying certain intuitive conditions) a small innovation always is licensed if the two firms initially share common costs, and that the set of parameters for which licensing obtains is strictly smaller than the set that gives rise to monopoly in the absence of licensing.

FIGURE 1

South Welfare: Protection vs. No-Protection

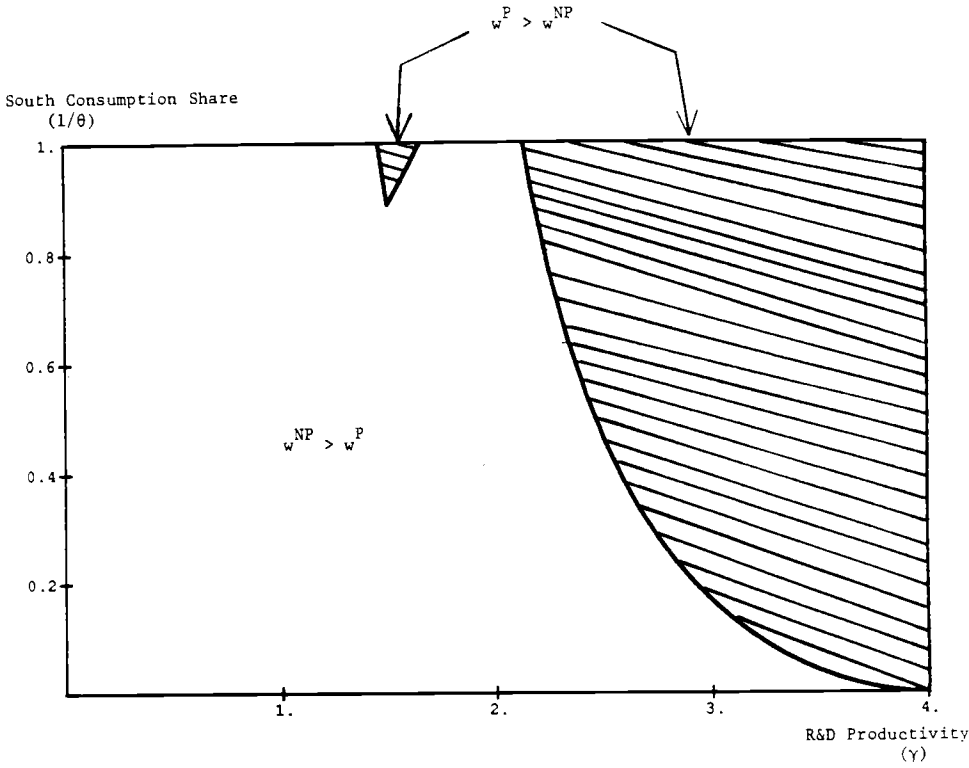

FIGURE 2

South Welfare with Licensing (σ=1)

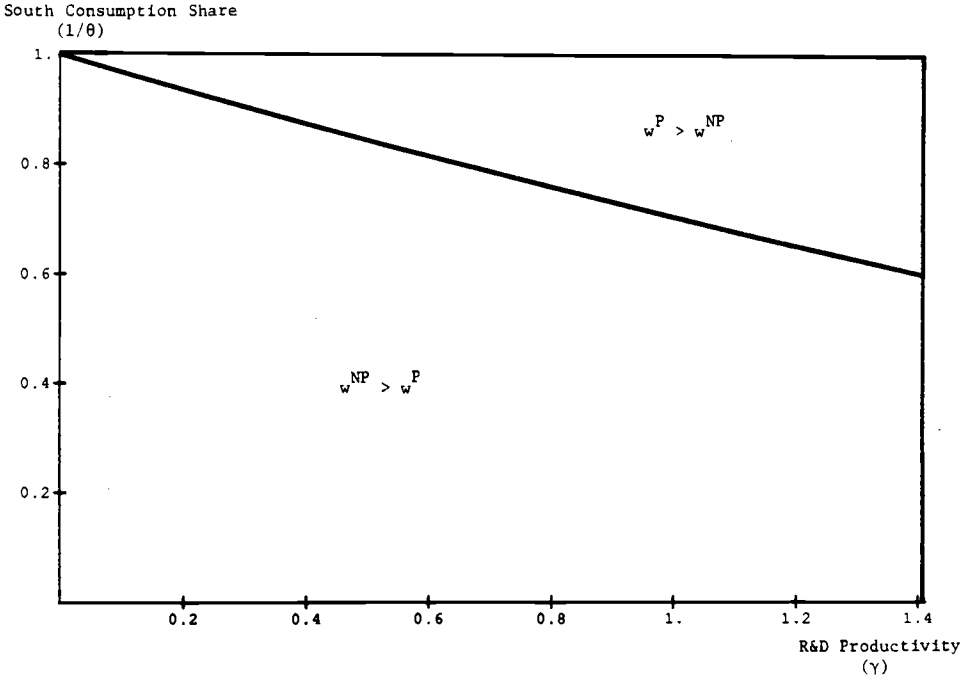

FIGURE 3

South Welfare with Licensing (σ=0)

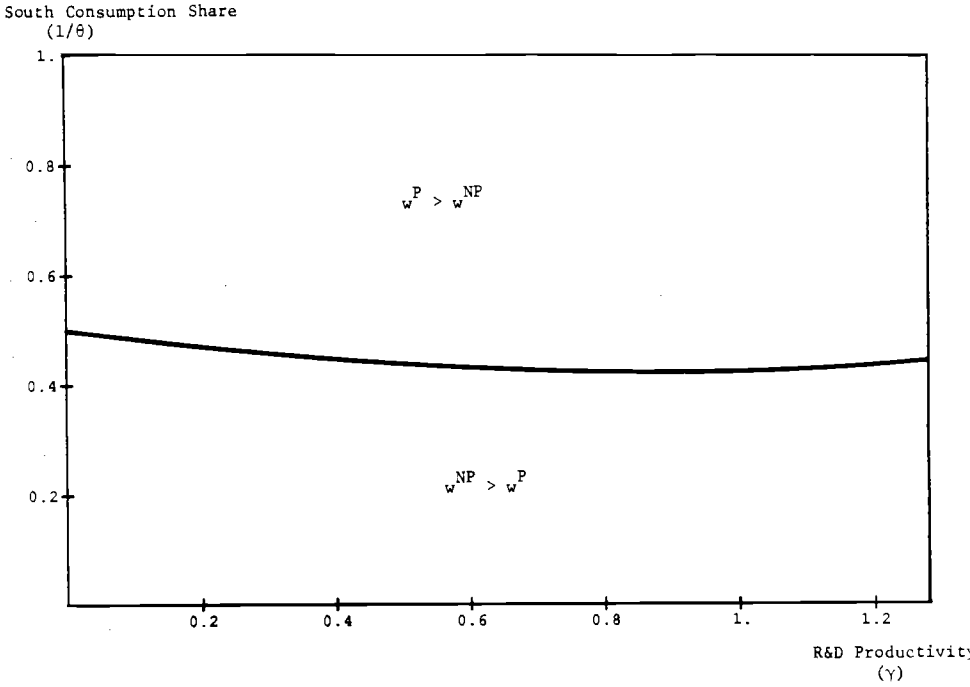

FIGURE 4

South Welfare with Licensing ($\sigma=\frac{1}{2}$)