Protecting Social Interest in Free Invention

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ABSTRACT

Although industrialized countries have increasingly pressured developing countries to tighten the protection of intellectual property, recent economic literature has questioned whether the developing countries should give into such pressure. The literature has found that for an invention-importing country, where domestic invention is scarce or nonexistent, protection of intellectual property developed elsewhere can reduce the country's welfare and, in some cases, world welfare. The analysis presented here concludes that this finding may not be applicable to products, such as antibiotics, fungicides, herbicides and pesticides, whose effectiveness diminishes with cumulative use. Protecting the intellectual property rights for these products can increase welfare--even when invention is provided for free.

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I. INTRODUCTION

In the Uruguay Round of Multilateral Trade Negotiations, industrialized nations have focused on placing intellectual property rights under the auspices of the General Agreement on Tariffs and Trade (GATT). These nations want to use the GATT as a tool to motivate countries that weakly protect intellectual property, chiefly the developing countries, to protect intellectual property rights more strongly. At the same time, the developing countries find it attractive to continue using invention and innovation in the industrialized world without paying for it.

One of the assertions typically made in arguments favoring protection of intellectual property rights is that inventors invent for financial gain. Protection of intellectual property helps inventors to gain from invention and motivates them to do so. At the same time, the protection of intellectual property rights creates a monopoly for the inventor which reduces welfare. Most analysts see monopoly as the cost of stimulating invention.

Recent economic literature (such as Chin and Grossman, 1988; Diwan and Rodrik, 1991; and Deardorff, 1992), however, calls into question whether developing countries ought to respond to pressure from the industrialized countries to protect intellectual property rights. In an invention-importing country, where domestic invention is scarce or nonexistent, protection of intellectual property developed elsewhere can reduce the country's welfare and, in some cases, world welfare. The principal assumption motivating these conclusions is that markets in the industrialized countries are large enough that offering protection of intellectual property in the developing country adds only slightly to the incentives for invention and innovation in the industrialized world. Therefore, intellectual property protection implies monopoly costs to the consumer that are not matched by rewards to motivate either local or foreign inventors.[1]

These findings appear consistent with empirical observation. Butler (1990) notes that, as of 1988, 47 countries did not patent pharmaceutical products, 59 did not patent animal varieties, 57 did not patent plant varieties, and 21 did not patent chemical products. The large majority of these countries are nonindustrial. In addition, Gadbaw and Richards (1988), Gadbaw and Kenny (1988), Richards (1988), and Sherwood (1990) find considerable evidence of industrial countries continuing to innovate even after developing countries have appropriated their technology without compensation.

It is, perhaps, ironic that pharmaceutical innovation has received particular attention in the much of the empirical work noted above. For some pharmaceuticals, namely antibiotics, developing countries may find it to desirable to protect intellectual property rights--even if invention is costlessly provided by divine intervention, pure altruism or dumb luck. Instead, many of these countries have compromised the effectiveness of some antibiotics, and other products with similar characteristics, by failing to protect ownership of the right to produce these products.

For a class of products, such as antibiotics, fungicides, herbicides and pesticides, effectiveness diminishes with cumulative use. For products such as these, consumption by one individual can impose an externality cost on society which competitive consumers and producers operating in a regime without protection of intellectual property rights would not take into account. As a consequence, product effectiveness is depleted at a faster than socially optimal rate, as resistant strains of bacteria, fungi, weeds and pests are developed.

In contrast, a monopoly producer, who owns the intellectual property right to such a product, has an economic incentive to preserve product effectiveness. The monopolist takes into account how one individual's consumption affects future effectiveness and consequent product demand. In doing so, the monopolist internalizes the externality and better preserves the product for the future. This finding has important implications for the Uruguay Round negotiations, or any other trade negotiations involving intellectual property.

II. AN ANALYTICAL MODEL

We develop an analytical model of the market for a product whose effectiveness diminishes with cumulative use. In this model, invention is costlessly bestowed under two types of policy regimes, one without intellectual property protection and one with it. In the regime without intellectual property protection, all producers have equal claim on the invention, and they produce in a competitive market. In the regime with intellectual property protection, the invention is bestowed on a single producer who gains a monopoly.

We begin by presenting demand and supply conditions for the product. We next develop the social welfare maximizing conditions for the market. We then compare these optimality conditions with the conditions that would prevail in a competitive market (with no intellectual property protection) and a monopolized market (with intellectual property protection). Finally, we conclude by comparing the competitive and monopolistic cases.

DEMAND

The quantity demanded at any moment in time (Q_t) is a function of price (P_t) and product effectiveness (E_t):

$$Q_t = Q(P_t, E_t) \tag{1}$$

where $\partial Q_t/\partial P_t < 0$ and $\partial Q_t/\partial E_t > 0$.[2]

Natural selection drives the process in which antibiotics, fungicides, herbicides and pesticides lose effectiveness with cumulative use over time. Effective use of such a product can destroy all or most of the target population of bacteria, fungus, weeds or pests in a given ecological niche. In some cases, small numbers of the target population will survive--that is strains that are resistant to the antibiotic or pesticide in use. With the ecological niche cleared of competing members of the target population, the resistant strain has a greater opportunity to multiply and fill the ecological niche. Eventually, the resistant strains will take over the ecological niche and spread to other similar environments. As this happens, the antibiotic, fungicide, herbicide or pesticide being used loses its effectiveness. Low-valued uses may accelerate the process in which a product loses effectiveness.

We simplify the process by assuming that product effectiveness at any moment in time is a decreasing function of cumulative consumption to date, X_t:

$$E_t = E(X_t) \tag{2}$$

where $\partial E_t/\partial X_t < 0$.

At any moment in time, cumulative consumption to date is defined:

$$X_t \equiv \int_0^t Q_\tau \, \partial\tau$$

where τ is a dummy of integration for t (time) and Q_t is the time derivative (rate of change) of X_t.

For analytical convenience, we rewrite demand as an inverse function, incorporating $E(X_t)$ in place of E_t

$$P_t = D(Q_t, X_t) \tag{3}$$

where $\partial P_t/\partial Q_t < 0$ and $\partial P_t/\partial X_t < 0$.

SUPPLY

Production occurs in n identical plants so that the total quantity produced at any moment in time (Q_t) is simply the number of plants (n) times the quantity produced in each plant (q):

$$Q_t = n q_t \tag{4}$$

For an individual firm, the total cost of production (c) is simply expressed as a function of output (q):

$$c_t = c(q_t) \tag{5}$$

where marginal cost is positive, $\partial c/\partial q > 0$. If output is distributed efficiently across all n plants, the aggregate total cost of production (C_t) can be written as a function of either Q or q.[3]

$$C_t = C(Q_t) = n \bullet c(q_t) \tag{6}$$

SOCIAL WELFARE MAXIMIZATION

The optimality conditions for social welfare maximization serve as a benchmark against which competition and monopoly can be compared. Social welfare can be written as the present discounted value of the sum of consumer and producer surplus, evaluated over time:

$$PVSW = \int_0^\infty e^{-rt}\int_0^Q [D(\chi, X) - C_\chi)\ \partial\chi\partial t \tag{7}$$

where r is the interest rate, χ is a dummy of integration for quantity (Q) and C_χ is defined as $\partial C/\partial\chi$. (To simplify notation, we drop the time subscript at this point in the analysis. It should be understood as implicit.)

Pontryagin's maximum principle (and some manipulation) yields the following optimality condition for social welfare maximization:

$$P = C_Q + \lambda \tag{8}$$

Price (P) equals marginal cost (C_Q) plus a user cost (λ).[4]

The user cost represents the marginal value of preserving effectiveness for future periods as follows:

$$\lambda = -e^{rt}\int_t^\infty (P_X e^{-r\tau})\,\partial\tau \tag{9}$$

where P_X is defined as $\partial P/\partial X$. If cumulative consumption reduces effectiveness, the price consumers are willing to pay for the product falls with cumulative production, then $P_X < 0$, and the user cost is positive. If cumulative consumption does not alter effectiveness, then $P_X = 0$, the user cost is zero, and equation (8) becomes the familiar optimality condition where price equals marginal cost.

The optimality conditions also indicate that the user cost can increase or decrease in value over time. In particular,

$$\dot{\lambda} = r \lambda + P_x \tag{10}$$

which, given that $P_x < 0$, indicates that the user cost grows more slowly than the interest rate, and declines if P_x is sufficiently negative.

The optimality condition expressed in equation (8) serves as a benchmark against which we compare the competitive and monopolistic cases.

COMPETITIVE CASE

In a purely competitive case, product effectiveness influences demand, but individual consumers and producers ignore the effect that individual consumption has on future effectiveness.

In the competitive case, inverse demand remains:

$$P = D(Q, X) \tag{11}$$

For each firm, profit maximizing conditions are obtained at the output where the firm's marginal cost equals the market price:

$$P = c_q \tag{12}$$

With n identical firms, market clearing conditions require that the quantity demanded (Q) equal the total quantity produced (n•q) at the market clearing price (P). Given the cost function (6) and Q = nq, it can be shown that C_Q equals c_q. Therefore competition yields the familiar case in which price equals marginal cost:

$$P = C_Q \tag{13}$$

This familiar case is not optimal, however. With consumers and producers ignoring the externality effects that consumption has on future effectiveness, the user cost found in equation (8) does not arise. Figure 1 illustrates the effect for a *given* demand curve at any moment in time. P* and Q* are the socially optimal price and quantity, respectively. For the given demand curve, the competitive market will yield a lower price, P_c, and a higher quantity, Q_c, than is socially optimal.

Comparing the dynamics of the competitive case with those of the socially optimal case is somewhat more complicated. Because the competitive market would produce above the socially optimal rate, the demand curve shifts inward more rapidly than for the optimal case. At some point in time, demand in the competitive case will have shifted inward enough more that output, Q, will be lower than if use of the product had always been managed in a socially optimal fashion. This condition will be maintained thereafter until product effectiveness goes to zero. Nevertheless, at any moment in time, the cumulative consumption to date, X, would be greater and the price would be lower under the competitive time path than under the socially optimal time path.

The competitive case can be made socially optimal by imposing a tax equal to the user cost or identifying and banning low-value uses. Implementing such a tax or restricting use of the product may be problematic if the political rate of discount is higher than the social rate. In cases where political discount rates are sufficiently high, political actors may be unwilling or unable to optimally defer consumer use of the product.

MONOPOLISTIC CASE

In the monopolistic case, the single seller has an incentive to consider how current consumption affects future effectiveness because the loss in effectiveness will be reflected in future sales. At the same time, however, a monopolist has the incentive to earn monopolistic rents by restricting output.

The monopolist's profit is described as:

$$\pi = \int_0^\infty e^{-rt} [P(Q, X) \bullet Q - C(Q)] \partial\tau \tag{14}$$

Pontryagin's maximum principle (and some manipulation) yields the monopolist's profit-maximizing condition as follows:

$$P + P_Q \bullet Q = C_Q + \lambda \tag{15}$$

Marginal revenue ($P + P_Q Q$) equals marginal cost (C_Q), plus the user cost (λ). Where P_Q is the reduction in price require to sell the marginal unit. Equations (9) and (10) above describe the user cost.

The presence of the user cost in equation (15) shows that the monopolist takes into account how current consumption affects future effectiveness. At the same time, however, the monopolist also restricts output to obtain a monopoly rent. Figure 1 illustrates monopolistic behavior for a *given* demand curve at any moment in time. P* and Q* remain the socially optimal price and quantity. For the given demand curve, the monopolist will set a higher price, P_M, and sell a smaller quantity, Q_M, than is optimal. (The monopolist obtains a marginal revenue of MR_M.)

Comparing the dynamics of the monopolistic case with those of the socially optimal case is somewhat more complicated. Because the monopolist would produce below the socially optimal rate, the demand curve will shift inward less rapidly than for the optimal case. At some point in time, demand in the monopolistic case will have shifted inward enough less that output, Q, will be higher than if use of the product had always been managed in a socially optimal fashion. This condition will be maintained thereafter until the product effectiveness goes to zero. Nevertheless, at any moment in time, the cumulative consumption to date, X, would be lower and the price would be higher under the monopolistic time path than under the socially optimal time path.

One method of encouraging the monopolist to behave in a socially optimal manner is to establish a government mandated price path in which the market-clearing price in each period is set equal to marginal cost plus user cost. With a set price path, the monopolist would face a perfectly elastic demand, and the incentive to restrict output would be eliminated. Setting such a price path would require considerable information about demand and true production costs. In addition, such a policy is rife with problems of political influence because the monopolist would have an incentive to lobby government officials to raise the regulated price above the optimal level.

An alternative approach for achieving optimality in the monopolistic case, is to offer the monopolist a production subsidy equal to $-P_QQ$. The government could avoid making a transfer to the monopolist by auctioning off permanent rights to monopolize the product's market with the government subsidy in place. Under competitive bidding, the monopoly rents and subsidies would be recaptured by the government. Of course, such a solution requires a credible commitment on the part of the government to honor the contract.

III. CONCLUSION: COMPETITION V. MONOPOLY

As shown above, neither competition nor monopoly is consistent with social welfare maximization when the product's effectiveness declines with cumulative use. A competitive industry would charge too low a price and deplete the product's effectiveness too rapidly. A monopolist would charge too high a price and produce too little of the product.

Our results are broadly consistent with those of Chin and Grossman, Diwan and Rodrik, and Deardorff. They find that a competitive industry would provide too little invention, and a monopoly too little output, to maximize social welfare. In their analysis, competition is preferable to monopoly because the welfare cost of the lost stimulus to invent is less than the welfare cost of restricted output.

In our case, competition is preferable to monopoly when the welfare cost of failing to protect product effectiveness is less than the welfare cost of restricted output. On the other hand, monopoly is preferable to competition when the welfare cost of failing to protect product effectiveness is more than the welfare cost of restricted output. We are unable to put prior values on these costs other than to say they depend on the elasticity of demand and the rate at which product effectiveness is depleted through cumulative use. In some cases, a monopoly that protects intellectual property may be preferable to competition, even when invention is costlessly provided.

If we simultaneously consider both the incentive to invent and the depletion of product effectiveness, competition would result in too little invention *and* too rapid depletion of product effectiveness. A monopolist would produce too little of the product.[5] As a consequence, the case for protecting intellectual property rights is substantially stronger for products whose effectiveness is depleted with cumulative use.

An even stronger case can be made for government intervention in the market for a product whose effectiveness diminishes with use--whatever the regime of intellectual property rights and market structure. Government intervention can improve the allocation of a product whose effectiveness diminishes with cumulative use in either a competitive or monopolistic case. The competitive market's allocation of the product can be improved through either the imposition of a tax equal to the optimal user cost or a ban on low-valued uses. The monopolist's allocation of the product can be improved through either a production subsidy or the imposition of the optimal price path. Of course, informational and political factors can inhibit the optimal application of such policies.

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NOTES

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1. Diwan and Rodrik (1991) and Frischstak (1990) find that developing countries can improve their welfare by protecting intellectual property when they have a strong demand for a product that is not particularly useful in the industrialized countries.

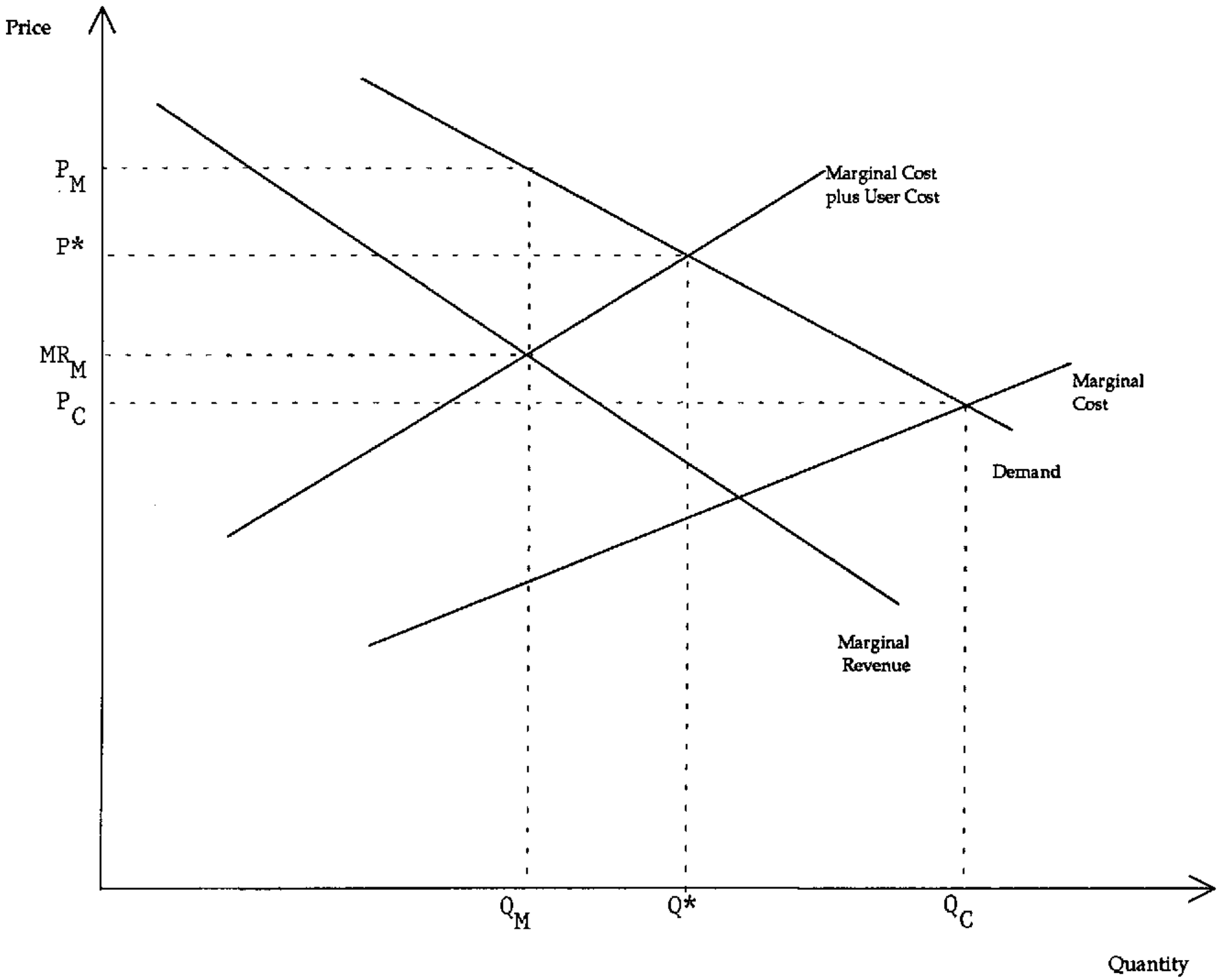
2. Over some ranges of effectiveness, consumers may increase their use of an antibiotic, fungicide, herbicide or pesticide to offset reduced effectiveness. We abstract from this case by assuming that they would do so only at a reduced price. Therefore, at a given price, consumption falls with effectiveness.

3. For simplicity, we assume the same number of plants in all three cases. This assumption simplifies the analysis without affecting the results.

4. This optimality condition should be familiar to those who are versed in the economics of exhaustible natural resources. See Dasgupta and Heal (1979).

5. The monopolist's incentive to restrict output may be limited, however, by the potential entry of competing inventions. See Baumol, et. al. (1988).

Figure 1



Price
P
M
P*
MR
M
P
C
Marginal Cost
plus User Cost
Marginal
Cost
Demand
Marginal
Revenue
Q
M
Q*
Q
C
Quantity

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