Intellectual Property Rights and Product Effectiveness

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Yet both developed and developing countries may have another reason to protect intellectual property—preserving product effectiveness.

In the Uruguay round of multilateral trade negotiations, industrialized nations focused on using the General Agreement on Tariffs and Trade (GATT) to increase the protection of intellectual property rights in developing countries. Representatives of developed countries have long claimed that the protection of intellectual property in developing countries raises welfare for all parties (Vishwasrao 1994). In contrast, recent theoretical literature (Chin and Grossman 1988, Diwan and Rodrik 1991, Deardorff 1992, and Helpman 1993) argues that in an invention-importing country, where domestic invention is scarce or nonexistent, the protection of intellectual property can reduce the country's welfare and, in some cases, world welfare.

An important assumption of this literature is that the only return to society from protecting intellectual property is that it stimulates inventors to invent. In the developing world, however, human capital is assumed to be insufficient to produce many inventions. In addition, markets in the industrialized countries can be large enough that offering protection for intellectual property in developing countries adds little incentive for invention in the industrialized world.[1] Therefore, intellectual property protection is likely to imply monopoly costs to consumers in developing countries, without providing much stimulus for either local or foreign invention.[2] Using this approach, Nogués (1993) contributes empirical evidence that patent protection for pharmaceuticals can reduce welfare in developing countries.

Yet both developed and developing countries may have another reason to protect intellectual property—preserving product effectiveness. This reason for protection has not been addressed in previous literature. For a wide range of products, such as antibiotics, fungicides, herbicides, and pesticides, effectiveness diminishes with cumulative use. Ironically, such products have been among the least likely to receive intellectual property protection in nonindustrial countries (Butler 1990). Furthermore, developed countries generally let the protection of intellectual property rights for all products expire after a set period. Neither course is optimal.

To highlight the importance of preserving product effectiveness, we present a model in which the entire world shares a characteristic that most analysts ascribe only to developing countries: invention is not motivated by financial gain. Invention is costlessly bestowed through divine intervention, pure altruism, or dumb luck. Nonetheless, we show that protection of intellectual property remains necessary to optimize social welfare.

In the model, the absence of intellectual property protection permits a competitive market to develop for a product whose effectiveness diminishes with cumulative use. The deterioration of product effectiveness yields an externality cost that neither consumers nor producers take into account. As a consequence, product effectiveness is depleted at a faster than optimal rate, as resistant strains of bacteria, fungi, weeds, and pests develop.

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 use affects future effectiveness and consequent product demand. In doing so, the monopolist internalizes the externality and acts to preserve the product's effectiveness for future use. These findings have important implications for domestic patent protection, as well as for trade negotiations, which increasingly involve intellectual property rights.

An analytical model

The model characterizes the market for a product whose effectiveness diminishes with cumulative use. 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):

(1) $$Q_t = Q(P_t, E_t),$$

where $\partial Q_t / \partial P_t < 0$ and $\partial Q_t / \partial E_t > 0$.[3]

Natural selection drives the process by which antibiotics, fungicides, herbicides, and pesticides lose effectiveness through cumulative use. 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 survive; these are strains that are resistant to the product in use. With the ecological niche cleared of competing members of the target population, resistant strains multiply and fill the niche. Eventually, resistant strains take over the niche and spread to other environments. As this happens, the antibiotic, fungicide, herbicide, or pesticide in use loses its effectiveness. Low-value uses 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:

(2) $$E_t = E(X_t),$$

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_τ 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:

(3) $$P_t = D(Q_t, X_t),$$

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

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

(4) $$Q_t = nq_t.$$

For an individual plant, the total cost of production (c) is a function of output (q):

(5) $$c_t = c(q_t),$$

where marginal cost is positive—that is, $\partial c / \partial q > 0$. 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:[4]

(6) $$C_t = C(Q_t) = n \cdot c(q_t).$$

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

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

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; it is implicit.)

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

$$(8) \qquad P = C_Q + \lambda.$$

Price (P) equals marginal cost (C_Q) plus a user cost (λ).[5]

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

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

where P_X is defined as $\partial P / \partial X$. If cumulative use reduces effectiveness, the price consumers are willing to pay for the product falls with cumulative production, $P_X < 0$, 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 in which price equals marginal cost.

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

$$(10) \qquad \dot{\lambda} = r\lambda + P_X,$$

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

$$(11) \qquad P = D(Q, X).$$

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

$$(12) \qquad P = c_q.$$

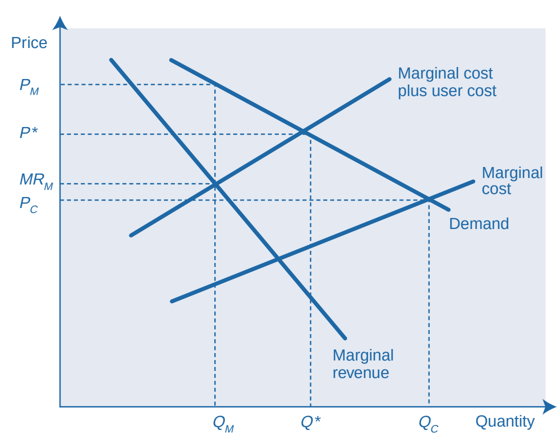
With n identical firms, market-clearing conditions require that the quantity demanded (Q) equals the total quantity produced ($n \cdot q$) at the market-clearing price (P). Given the cost function, equation 6, and $Q = nq$, it can be shown that C_Q equals c_q. Therefore, competition yields the familiar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

$$(13) \qquad P = C_Q.$$

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 more complicated. Because the competitive market produces above the socially optimal rate, the demand curve shifts inward more rapidly than in the optimal case. At some point in time, demand in the competitive case will have shifted inward enough more that output,

Figure 1
Supply and Demand



Q, will be lower than if use of the product had always been optimal. This condition continues thereafter until product effectiveness goes to zero. Nevertheless, on the competitive time path, the cumulative consumption to date, X, will always be greater and the price will be lower than on the socially optimal time path.

Although intellectual property protection optimizes social welfare, the no-protection, competitive case can be made socially optimal by imposing a tax equal to the user cost or by identifying and banning low-value uses. The trouble with these solutions is that political time horizons and pressures may render political actors unwilling or unable to optimally defer product use either through higher prices or by proscribing low-value uses.

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

(14) $$\Pi = \int_0^{\infty} e^{-rt} [P(Q, X) \cdot Q - C(Q)] \, \partial t.$$

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

(15) $$P + P_Q \cdot Q = C_Q + \lambda.$$

Marginal revenue ($P + P_Q Q$) equals marginal cost (C_Q) plus the user cost (λ), where P_Q is the reduction in price required to sell the marginal unit. Equations 9 and 10 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 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, respectively. For the given demand curve, the monopolist sets a higher price, P_M, and sells 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 one is more complicated. Because the monopolist produces below the socially optimal rate, the demand curve shifts inward less rapidly than in 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 product effectiveness goes to zero. Nevertheless, on the monopolistic time path, cumulative consumption to date, X, will always be lower and the price will always be higher than on the socially optimal time path.

One way to encourage the monopolist to allocate the product 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 faces a perfectly elastic demand, and the incentive to restrict output disappears. Setting such a price path requires considerable information about demand and true production costs. In addition, such a policy could be rife with political influence because the monopolist would have an incentive to lobby government officials to raise the regulated price above the optimal level.

A more politic approach is to offer the monopolist a production subsidy equal to $-P_Q Q$. The government can 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. This policy can solve the allocation problem only if the government commitment to honor the contract is credible. We do not address time inconsistency problems here.

Conclusion: Competition versus monopoly

As shown above, neither competition nor monopoly is consistent with social welfare maximization when a 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, Deardorff, and Helpman. They find that a competitive industry would provide too little invention, and a monopoly too little output, to maximize social welfare. But in their analyses, competition is preferable to monopoly when the welfare cost of the lost stimulus to invent is less than the welfare cost of restricted output.

In our analysis, competition is preferable to monopoly when the welfare cost of failing to protect product effectiveness is less than the welfare cost of restricted output. 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 will result in too little invention *and* too rapid depletion of product effectiveness. A monopolist will produce too little of the product.[6] In addition, Vishwasrao shows that the gains to developed countries in avoiding monopoly pricing through patent infringement may be limited.[7] As a consequence, the case for protecting intellectual property rights is substantially stronger for products whose effectiveness is depleted with cumulative use. Products with this characteristic—antibiotics, fungicides, herbicides, and pesticides—have been among the least likely to receive patent protection in developing countries.

Notes

The authors would like to thank Zsolt Becsi, Alan V. Deardorff, Evan Koenig, Roy Ruffin, and Carlos Zarazaga for helpful comments on earlier drafts, without implicating them in any shortcomings of the analysis.

1 Taylor (1994) underscores the importance of incentives by showing that an invention-importing country can slow technological progress and make both itself and the world worse off when its failure to protect intellectual property developed elsewhere reduces the incentive to invent elsewhere.

2 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 industrialized countries.

3 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.

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

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

6 The monopolist's incentive to restrict output may be limited, however, by the potential entry of competing inventions. The extent of competition may depend on the breadth of patent protection and the cost of imitation. See Baumol and Willig (1981), Baumol, Panzar, and Willig (1988), Gallini (1992), Gilbert and Shapiro (1990), and Klemperer (1990).

7 Vishwasrao shows that a lack of patent protection can adversely affect the licensing of low-cost technologies to developing countries and that strategic behavior on the part of firms in developed countries can erode the gains developing countries reap through patent infringement.

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