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PART FIVE: Developing Countries

22. Agricultural Biotechnology in Developing Countries: Will It Be Technology Transferred Through the Market or Piracy?

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Chapter 22

Agricultural Biotechnology in Developing Countries: Will It Be Technology Transferred Through the Market or Piracy?

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Introduction

The failure to enforce intellectual property rights in developing countries has become a major international issue. This is because the revolutions in computer technology and biotechnology have meant that, over the last two decades, the proportion of the value of goods accounted for by intellectual property has been rising. While most research and development takes place in developed countries, large markets exist in developing countries and the capacity to produce and export pirate products in many developing countries has been increasing. As a result, firms engaged in the legitimate production of intellectual property-intensive goods have actively lobbied their governments to press for improvements to the international protection of intellectual property. Governments in developed countries also realize that their continued relative prosperity is directly tied to intellectual property-enhancing investments in areas such as biotechnology, hence activities which inhibit those investments, such as piracy, can have significant detrimental effects on a country's growth and economic leadership.

The most visible expression of this concern was the entire restructuring of the General Agreement on Tariffs and Trade (GATT) at the Uruguay Round to, in part, include intellectual property protection. An Agreement on Trade Related Aspects of Intellectual Property (TRIPs) was concluded which is administered by the new World Trade Organization (WTO). One of the central elements of the new structure was to explicitly allow trade sanctions under the GATT (now also administered by the WTO) to be used as retaliation for violation of TRIPs commitments. Developed countries expected that the threat of formal trade sanctions would induce developing countries to protect intellectual property - the previous World Intellectual Property Organization (WIPO) had no enforcement mechanism (Braga 1995).

Developing countries have expressed wide ranging concerns regarding patent protection for agricultural biotechnology for reasons of food security, anti competitive practices of agrobiotechnology firms and threats to the environment (Ringo 1994). They hold general reservations relating to the patenting of life forms and agricultural crops in particular. Due to these concerns, the TRIPs contains an exception (meaning countries can choose not to enforce intellectual property rights without fear of trade retaliation) for *plants and animals (other than micro-organisms) and essentially biological processes for the production of plants and animals, other than non-biological and microbiological processes* (TRIPs Article 27 (3)). Plant varieties, however, must be protected either by patents or a system of plant breeders' rights. Products developed using biotechnology are to be given protection. The exact boundaries of what can be exempted has yet to be determined. Even if protection for biotechnology is provided in their domestic intellectual property legislation (due to, for example, bilateral pressure) a question still arises regarding whether governments will actively enforce intellectual property laws. A five year period of grace was included in the 1994 TRIPs so that its provisions will not be tested until sometime in the 21st century. While legislation providing for compliance with TRIPs commitments is being put in place in most developing countries, little research has been conducted into the likely efficacy of TRIPs for the protection of agricultural biotechnology.

This paper develops a model which is sufficiently broad to examine cases where countries may choose to attempt to exercise their rights of exclusion (to not extend intellectual property protection) and no trade threat exists and where countries include protection for agricultural biotechnology but have a choice whether or not to enforce.

The Model

A firm in a developed country has created an agricultural biotechnology product which required an investment in research and development and for which the firm extracts monopoly profits in its home market due to strong protection of intellectual property rights. The firm also allows legitimate production in a developing country with the payment of a royalty on a per unit basis. The firm could also produce the product domestically and export it or it could invest directly in the developing country by constructing its own plant to produce the product. We focus on the first case.

This analysis looks at the market in the developing country in isolation. To enforce this limitation we assume that the product is costlessly tailored to the developing country's market making it worthless in any other market. For example, the product could be biotechnology which has already been developed for temperate climates and which can be easily modified to meet the different climatic regions in the tropics.

We also assume the technology is costlessly reproducible through reverse engineering, hence, it is possible for firms in the developing country to produce the product without paying the royalty – i.e. pirate production.

Costs

Individual firms in the developing country, whether they produce the product legitimately or as a pirated output, are assumed to have an insignificant impact on the price and therefore act as perfect competitors. They take the price as a given and set output accordingly. The technology is such that the production of each unit of output costs α. Thus, both the average and the marginal production costs are constant and equal to α. Further, legitimate firms pay a per unit royalty equal to r.

The fully-loaded unit cost for the firms producing legitimate output (i.e. the per unit production cost plus the royalty rate) would therefore be:

$$[1] \qquad MC_L = AC_L = \alpha + r$$

Here, MC_L is the marginal cost of legitimate production and AC_L is the average cost of legitimate production.

The inverse supply function for the legitimate output is given by the long-run break even condition:

$$[2] \qquad P = \alpha + r$$

Free entry of legitimate firms serves to equate price, P, with unit costs.

Pirate producers have different unit costs, reflecting different factors affecting the production and distribution of pirated output. The marginal cost for pirated production is given by:

$$[3] \qquad MC_p = AC_p = \alpha + C + \beta Q_p$$

Here, MC_P is the marginal cost of pirate production and AC_P is the average cost of pirate production. In addition to the production costs α, pirate firms face an additional per unit cost related to having to conceal their production and marketing from being detected by domestic authorities and the foreign firm. Concealment costs per unit are given by C. The value for C is indirectly determined by the government of the developing country because as the effort of policing against piracy increases, so does the cost of concealment. Since pirate firms cannot market their production through legitimate distribution channels, there are additional costs associated with marketing. For a given pirate firm, we assume that the cost of marketing is proportional to the total production of all pirate firms. That is, the greater the total volume of pirate production, the more a given firm has to spend on getting its own production marketed. This marketing cost is given by βQ_P where β is a marketing cost parameter and Q_P is equal to the production of all pirates in aggregate. No single pirate firm has a significant influence over Q_P. Since the marginal cost is not dependent on the output of an individual pirate firm, it is also equal to the average cost of production.

If the pirate firm pays the concealment and marketing costs described above, it escapes specific observation with certainty. If the firm does not pay these costs, its output will be confiscated and destroyed with certainty. Simplification for modeling purposes means that we do not adjust for a fraction of pirate output being observed and confiscated.

It should be noted that even though individual firms may get away with piracy, the country may not. That is, upon detection at the point of sale, it may be extremely difficult to attribute the pirated product back to a specific pirate firm. On the other hand, any pirate product which is detected is evidence of piracy but the model does not assume that it will automatically result in conviction.

Since there is also free entry of pirate suppliers, price must also be equated with unit costs.

[4] $$P = \alpha + C + \beta Q_P$$

Equation [4] is the inverse supply function for pirate firms.

Market Equilibrium

We assume a total market demand given by:

[5] $$P = \delta - \gamma Q_D$$

The market for the product in the developing country is shown in Figure 1, where D is the market demand curve, S_P is the pirate supply curve and S_L is the legitimate supply curve. Q_D is total market demand for the product. Q_P is the total amount of the product supplied by pirate firms and Q_D - Q_P is equal to legitimate output.

To derive Q_D, we substitute equation [2] into equation [5]:

[6] $$P = \alpha + r = \delta - \gamma Q_D$$

[7] $$Q_D = \frac{\delta - \alpha - r}{\gamma}$$

To derive Q_P, we substitute equation [2] into equation [4]

[8] $$\alpha + r = \alpha + C + \beta Q_P$$

[9] $$Q_P = \frac{r - C}{\beta}$$

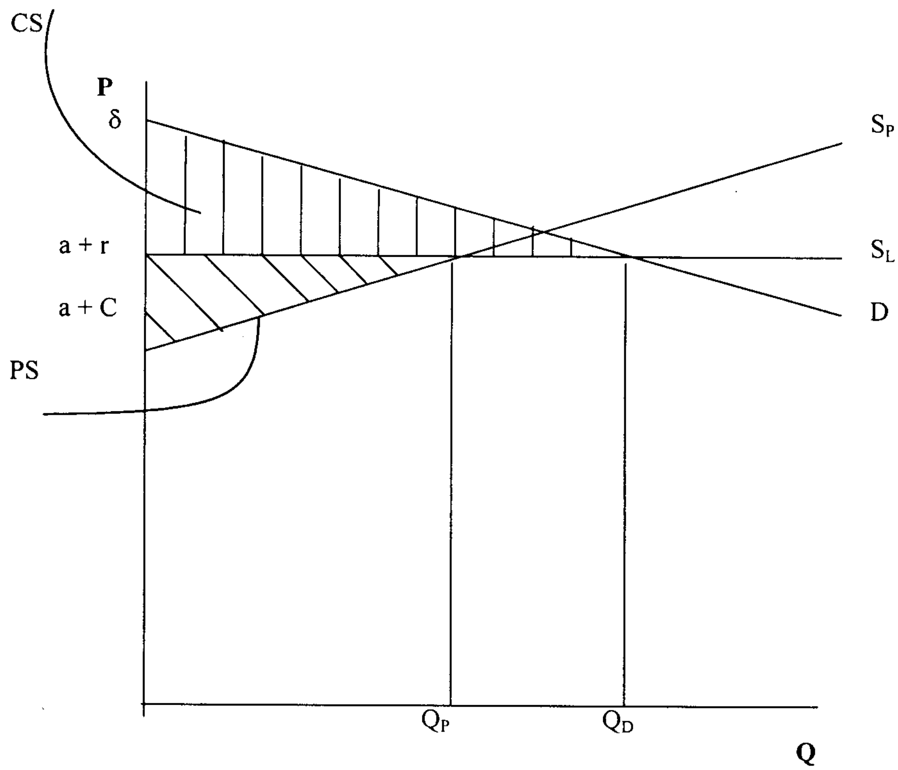
The area for the triangle of consumer surplus (CS in Figure 1) is given by:

[10] $$CS = (1/2) \cdot (\delta - (\alpha + r)) \cdot Q_D$$

Substituting in equation [7] yields:

[11] $$CS = (1/2) \cdot (\delta - (\alpha + r)) \cdot (\frac{\delta - \alpha - r}{\gamma})$$

FIGURE 1 Producer and Consumer Surplus in the Developing Country



[12] $$CS = (1/2)\frac{(\delta - \alpha - r)^2}{\gamma}$$

Producer surplus (PS) is given by:

[13] $$PS = (1/2)((\alpha + r) - (\alpha + C)) \cdot Q_D$$

Substituting in equation 9 yields:

[14] $$PS = (1/2)((\alpha + r) - (\alpha + C)) \cdot (\frac{r - C}{\beta})$$

[15] $$PS = (1/2)\frac{(r - C)^2}{\beta}$$

Welfare Maximizing Behavior of the Developing Country's Government

The total welfare function for the developing country is:

[16] $$W = CS + PS - ETP - DC$$

and equal to the sum of consumer and producer surplus less the expected trade penalty (ETP), given by:

[17] $$ETP = \theta \bullet TP$$

and less the direct cost of policing against pirate production (DC). The expected trade penalty is the penalty paid (TP) weighted by the probability of a penalty being applied (θ). The direct policing cost involves the cost to the government of extra policing resources required to detect piracy.

The probability of penalty is a joint probability comprised of the probability of detection or observation, the probability of the complaint going to the WTO and the probability of getting a decision which upholds the complaint from the dispute resolution panel. In other words, the owner of the intellectual property must obtain evidence of piracy and that evidence must be accepted by a WTO disputes panel. In this model, if piracy is observed it is assumed to be a matter of general knowledge. It should also be noted that we assume the owner of the intellectual property does not pay to enhance observation and the government does not pay to reduce observability.

We assume that the probability of penalty is a direct function of the total pirate output. We take the probability of penalty to be a simple linear function of the total pirate production.

[18] $$\theta = \min\{\rho \bullet Q_p, 1\}$$

If the probability parameter ρ is sufficiently low then the Nash equilibrium probability of penalty is always less than 100%. More specifically, for this analysis, we assume that:

[19] $$\rho < \frac{\delta - \alpha}{2(\beta + \gamma)}$$

This limitation on ρ is derived from comparison with the case where the probability of penalty is 100% (Tarvydas, 1997). The probability of penalty is given by:

[20] $$\theta = \rho \bullet Q_p$$

As a first approximation of the trade penalty which could be imposed by the WTO, we use a value equal to a fixed proportion ψ of the producer surplus. The trade penalty, as a multiple of the producer surplus generated by the pirate firms, is given by:

[21] $$TP = \psi \bullet PS$$

Note that when ψ is equal to zero, there is no risk of a penalty and therefore no possibility of enforcement. This is the case when an exception is exercised and unchallenged by the developing country in relation to an agricultural biotechnology product and no penalties can be imposed. If an exception is not chosen, ψ has a positive value but it cannot be infinite since it must have some relation to the infraction.

The WTO has not yet determined the basis upon which these penalties can be imposed for violations of TRIPs commitments. If GATT conventions, which set retaliatory penalties equal to the value of trade lost, are used as precedents for determining the penalties under TRIPs, the actual penalty would be based on pirate revenue. In this case, the penalty would become:

[22] $$\psi = \frac{Revenue}{PS}$$

Producer surplus is always a fraction of revenue and that fraction varies across countries. Thus, if the penalty is revenue based, the penalty parameter ψ must be greater than one and it could vary across industries.

In principle, the trade penalty could take many other forms. For example, it could be related to the loss of potential monopoly profits rather than the total revenue lost by the owner of the intellectual property. Thus, the value of the penalty parameter pertaining to a particular industry will ultimately depend on the practices established by the WTO.

We now turn to the calculation of the expected trade penalty. Recall from [17] that the expected trade penalty is given by the probability of the penalty multiplied by the trade penalty.

Making the substitutions from equations [20] and [21] into equation [17] yields:

[23] $$ETP = (\rho \bullet Q_p)(\psi \bullet PS)$$

Substituting in equations [9] and [15] yields:

[24] $$ETP = \frac{\rho\psi(r - C)^3}{2\beta^2}$$

The direct cost of enforcement, DC, is the cost associated with the government of the developing country having to hire extra police resources whose task is to expose piracy and extra administration staff to support the regulatory framework. We assume the cost of enforcement is related to the concealment cost. We set DC to be given by:

[25] $$DC = \phi \bullet C$$

Here, ϕ is a multiplier for the cost of concealment C. This formulation reflects the fact that higher expenditures on enforcement will result in higher concealment costs. Typically, higher expenditures on enforcement will lead to a lower expectation of being faced with a trade penalty. Conversely, lower expenditures on enforcement will lead to a higher expectation of being faced with a trade penalty[2].

Substituting into the welfare function for CS, PS, ETP and DC yields:

[26] $$W = \frac{(\delta - \alpha - r)^2}{2\gamma} + \frac{(r - C)^2}{2\beta} - \frac{\rho\psi(r - C)^3}{2\beta^2} - \phi C$$

Note that since welfare is a function of concealment costs, the government, in selecting a level of enforcement which maximizes welfare, indirectly chooses the level of concealment costs.

To find the optimal level of C for any given r, we need to develop the first order condition for the welfare function. Taking the derivative of the welfare function with respect to concealment costs yields the marginal welfare function for the government.

[27] $$\frac{\partial W}{\partial C} = -\frac{(r - C)}{\beta} + \frac{3\rho\psi(r - C)^2}{2\beta^2} - \phi$$

If we equate the marginal welfare function to zero, we get the first order condition for the government.

[28] $$0 = -\frac{(r - C)}{\beta} + \frac{3\rho\psi(r - C)^2}{2\beta^2} - \phi$$

The second order condition for the government is given by the second derivative with respect to concealment costs.

[29] $$\frac{\partial^2 W}{\partial C^2} = -\frac{1}{\beta} - \frac{6\rho\psi(r - C)}{2\beta^2} < 0$$

For the second order condition to hold, we need:

[30] $$r - C > \frac{\beta}{3\rho\psi}$$

We can solve equation [26] by using the quadratic formula.

[31] $$r - C = \frac{\frac{1}{\beta} \pm \sqrt{(\frac{1}{\beta})^2 - 4(\frac{3\rho\psi}{2\beta^2})(-\phi)}}{2(\frac{3\rho\psi}{2\beta^2})}$$

[32] $$r - C = \frac{\frac{1}{\beta} \pm \sqrt{(\frac{1}{\beta})^2 + (\frac{6\rho\psi\phi}{\beta^2})}}{(\frac{3\rho\psi}{\beta^2})}$$

This has two solutions given by:

[33] $$r - C = \frac{\beta(1+\sqrt{1+6\rho\psi\phi})}{3\rho\psi}, \frac{\beta(1-\sqrt{1+6\rho\psi\phi})}{3\rho\psi}$$

The second root violates the second order condition and therefore will not exist as a solution to the economic problem. More intuitively, when C is greater than r, the cost of concealment exceeds the cost of the royalty and there will be no pirate production. Of course, setting enforcement levels excessively high would not be rational.

The only reasonable solution to the quadratic is therefore given by:

[34] $$C = \begin{cases} 0 & \text{if } r < g_0 \\ -g_0 + r & \text{if } r \geq g_0 \end{cases}$$

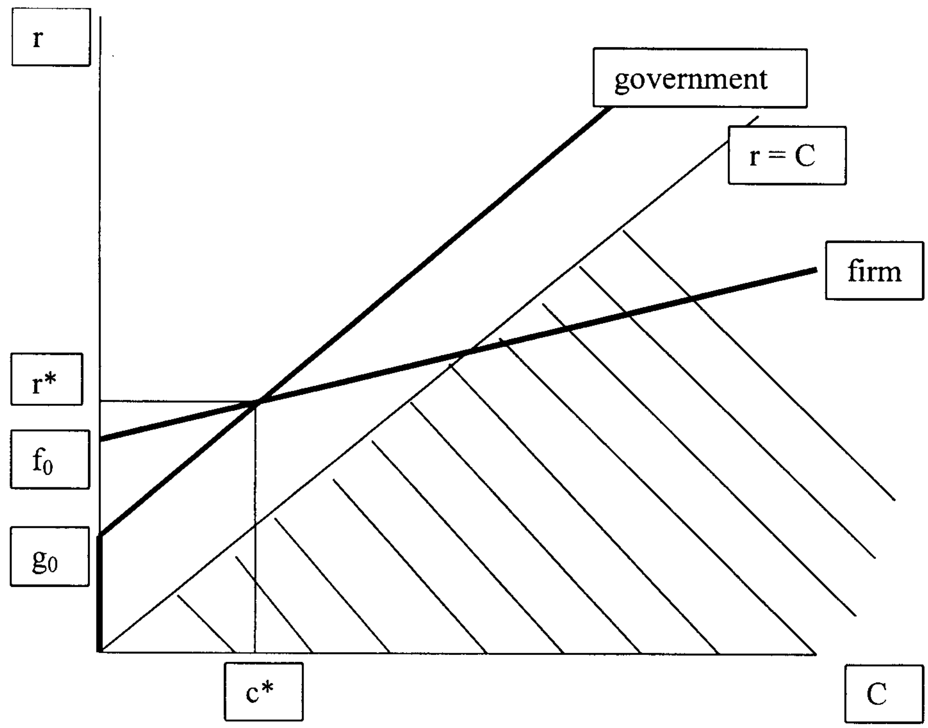
where g_0 is the intercept term and is given by:

[35] $$g_0 = \frac{\beta(1+\sqrt{1+6\rho\psi\phi})}{3\rho\psi}$$

Equation [33] is the reaction function for the government of the developing country. It indicates the optimum level of concealment, and hence enforcement, for any given level of royalty. As Figure 2 shows, the reaction function for the government is kinked since it has different values depending on r and g_0. When r is less than g_0, there will be no enforcement and therefore no concealment costs. When r is greater than or equal to g_0, there will be some enforcement and hence some concealment costs. Note also that the reaction function has a positive intercept and slope equal to one.

We can also determine the equilibrium values for Q_p and θ, given by Q^*_p and θ^* respectively, from equation [33].

FIGURE 2 Nash Equilibrium in the Royalty versus Enforcement Game



[36] $$Q_p^* = \frac{1+\sqrt{1+6\rho\psi\phi}}{3\rho\psi}$$

[37] $$\theta^* = \frac{1+\sqrt{1+6\rho\psi\phi}}{3\psi}$$

The partial derivatives of equations [36] and [37] with respect to ψ are negative. Higher values of the trade penalty will therefore result in lower values of Nash equilibrium pirate output and the Nash equilibrium probability of detection. The partial derivative of equation [36] with respect to ρ is negative. A higher probability of detection will therefore result in a lower pirate output. The partial derivative of equation [37] with respect to ρ is positive. A higher value for ρ will result in a higher probability of detection. The partial derivatives of equations [36] and [37] with respect to ϕ are positive. Higher enforcement costs result in higher levels of pirate output and a higher probability of detection.

Profit Maximizing Behavior for the Owner of Agricultural Biotechnology

We can also determine the profit function for the owner of the agricultural biotechnology:

[38] $$\pi_m = r(Q_D - Q_p)$$

Substituting for Q_D and Q_P

[39] $$\pi_m = \frac{r\beta\delta - r\beta\alpha - \beta r^2 - \gamma r^2 + \gamma rC}{\gamma\beta}$$

Taking the derivative of the profit function with respect to r yields the marginal profit function:

[40] $$\frac{\partial\pi_m}{\partial r} = \frac{\beta\delta - \beta\alpha - 2\beta r - 2\gamma r + \gamma C}{\gamma\beta}$$

We can set marginal profits equal to zero to obtain the first order condition for profit maximization.

[41] $$0 = \frac{\beta\delta - \beta\alpha - 2\beta r - 2\gamma r + \gamma C}{\gamma\beta}$$

[42] $$r = f_0 + f_1 C \qquad \text{for } C \geq 0$$

The terms of equation [41] are given by:

[43] $$f_0 = \frac{\beta(\delta - \alpha)}{2(\beta + \gamma)}$$

[44] $$0 < f_1 = \frac{\gamma}{2(\beta + \gamma)} < 1$$

Equation [42] is the reaction function of the owner of the agricultural technology. It indicates how the optimum royalty rate changes for any given level of enforcement. Note that unlike the reaction function for the government of the developing country, the reaction function of the firm which owns the agricultural biotechnology is not kinked. Note also that the reaction function for the firm has a positive linear slope which is less than one.

Nash Equilibrium in a Simultaneous Game

In a Nash equilibrium, each player is doing the best it can, given the strategies of the other players. For this case of the model, we assume that neither the firm which owns the agricultural biotechnology nor the government of the developing country can credibly act first and therefore the game is played simultaneously. In the next section we present the case of a leadership game where the firm can credibly commit to a royalty before the government commits to a level of enforcement.

To solve for the Nash equilibrium of the simultaneous game, we find the solutions to r and C given by equations [34] and [42]. Since the reaction function of the government has a kink in it, there will be two solutions: an internal solution where $f_0 > g_0$; and a boundary solution where $g_0 \geq f_0$. Both solutions are shown graphically in Figure 2.

For the portion of the graph where C is greater than r, there is no piracy and therefore full enforcement. When C is greater than r, the cost of concealment exceeds the cost of the royalty and there will be no pirate production. Of course, setting enforcement levels excessively high would not be rational.

We can solve for the internal solution by substituting [34] into [42].

[45] $$r^* = \frac{\beta\delta - \beta\alpha}{2(\beta+\gamma)} + \frac{\gamma}{2(\beta+\gamma)}(r - \frac{\beta(1+\sqrt{1+6\rho\psi\phi})}{3\rho\psi})$$

[46] $$r^* = \frac{3\rho\psi(\beta\delta - \beta\alpha) - \gamma\beta(1+\sqrt{1+6\rho\psi\phi}}{2(\beta+\gamma)}$$

[47] $$r^* = \frac{(\beta\delta - \beta\alpha)}{2(\beta+\gamma)} - \frac{\gamma\beta(1+\sqrt{1+6\rho\psi\phi})}{6\rho\psi(\beta+\gamma)}$$

Since the first term on the right hand side of [47] is greater than f_0 and the second term on the right hand side of [47] is less than g_0, and since f_0 - g_0 is positive for an internal solution, r* is positive.

Substituting back into equation [34] yields:

[48] $$C^* = \frac{3\rho\psi(\beta\delta - \beta\alpha) - \gamma\beta(1+\sqrt{1+6\rho\psi\phi})}{6\rho\psi(\beta+\gamma)} - \frac{\beta(1+\sqrt{1+6\rho\psi\phi})}{3\rho\psi}$$

[49] $$C^* = \frac{(\beta\delta - \beta\alpha)}{2(\beta+\gamma)} - \frac{(2\beta^2 + 2\beta\gamma)(1+\sqrt{1+6\rho\psi\phi})}{6\rho\psi(\beta+\gamma)}$$

To determine the impact of changing ρ, ψ, and ϕ on the government of the developing country and the firm which owns the agricultural biotechnology we need to determine how changing these factors affects equations [47] and [49]. The partial derivatives of equations [47] and [49] with respect to ρ and ψ are positive. When ρ and ψ increase, there is more enforcement and higher royalties. These results suggest that as the exogenous component of the probability of detection increases (i.e. ρ increases), both the Nash equilibrium concealment costs and royalties increase because the level of enforcement will be higher. Similarly, as the probability of the trade penalty increases (i.e. ψ gets larger), both the Nash equilibrium concealment costs and royalties will increase because the level of enforcement will be higher.

The partial derivatives of equations [47] and [49] with respect to ϕ are negative. When ϕ increases, there is therefore less enforcement and the royalties are lower. These results suggest that as the direct costs of enforcement increase, the government enforces less and therefore the concealment costs and royalties will be lower.

In order for there to be no pirate production, r would have to be equal to C. For r to equal C, g_0 must be equal to zero.

[50] $$\frac{\lim}{\psi \to \infty}, \Rightarrow g_0 = \frac{\beta(1+\sqrt{1+6\delta\psi\phi})}{3\rho\psi} = 0$$

Since it is not plausible to have infinite trade penalties, there will be no circumstances under which pirate production will be eliminated entirely.

If g_0 is greater than f_0, there will be a boundary solution rather than an interior solution. In the boundary solution, there is no interior point where the two reaction functions intersect and therefore no enforcement by the government in the developing country. As ψ moves to zero, g_0 grows to exceed f_0, and there is therefore no enforcement. The model thus predicts the case as it was under WIPO or when a government exercises its right to a TRIPs exemption. Further, even if ψ is greater than zero, there may still be no enforcement, i.e. if g_0 is greater than f_0. The presence of the trade penalty for infractions of intellectual property rights under the WTO may therefore not have any impact on the enforcement of these rights in developing countries. Technology will be transferred to the developing country, for the most part, by piracy.

Leadership Game

If we assume that the firm which owns the agricultural biotechnology can credibly act first, on the basis of its knowledge of the reaction function of the government in the developing country, and set its royalty rate, we have the case of a leadership game. The leadership game may be a preferred specification since it seems to represent a more realistic case of non-simultaneous behavior.

We can change the model to a leadership game by substituting the government's reaction function into the firm's profit function as follows:

[51] $$\pi_m = \frac{r\beta\delta - r\beta\alpha - \beta r^2 - \gamma r^2 + \gamma r\left(-\frac{\beta(1+\sqrt{1+6\rho\psi\phi})}{3\rho\psi} + r\right)}{\gamma\beta}$$

Now we take the partial derivative of the profit function with respect to r to obtain marginal profits.

[52] $$\frac{\partial\pi_m}{\partial r} = \frac{\beta\delta - \beta\alpha - 2\beta r + \gamma\left(-\frac{\beta(1+\sqrt{1+6\rho\psi\phi})}{3\rho\psi}\right)}{\gamma\beta}$$

Setting the marginal profits equal to zero to maximize profits yields:

[53] $$0 = \frac{\beta\delta - \beta\alpha - 2\beta r + \gamma\left(-\frac{\beta(1+\sqrt{1+6\rho\psi\phi})}{3\rho\psi}\right)}{\gamma\beta}$$

We can rearrange and solve for r**, the royalty rate that maximizes profits in the leadership game.

[54] $$r^{**} = \frac{\delta - \alpha}{2} - \gamma\left(\frac{(1+\sqrt{1+6\rho\psi\phi})}{6\rho\psi}\right)$$

We can compare the royalties in the leadership game, r**, to the royalties in the simultaneous game, r*, to determine the impact of staging the model as a leadership game. We can rewrite r* from equation [47] as:

[55] $$r^{*} = \frac{2\beta}{2\beta + \gamma}\left\{\frac{(\delta - \alpha)}{2} - \gamma\left(\frac{(1+\sqrt{1+6\rho\psi\phi})}{6\rho\psi}\right)\right\}$$

We can rewrite r** as:

[56] $$r^{**} = \frac{2\beta + \gamma}{2\beta} r^{*}$$

Since $(2\beta+\gamma)/2\beta$ is greater than one, r**>r*.

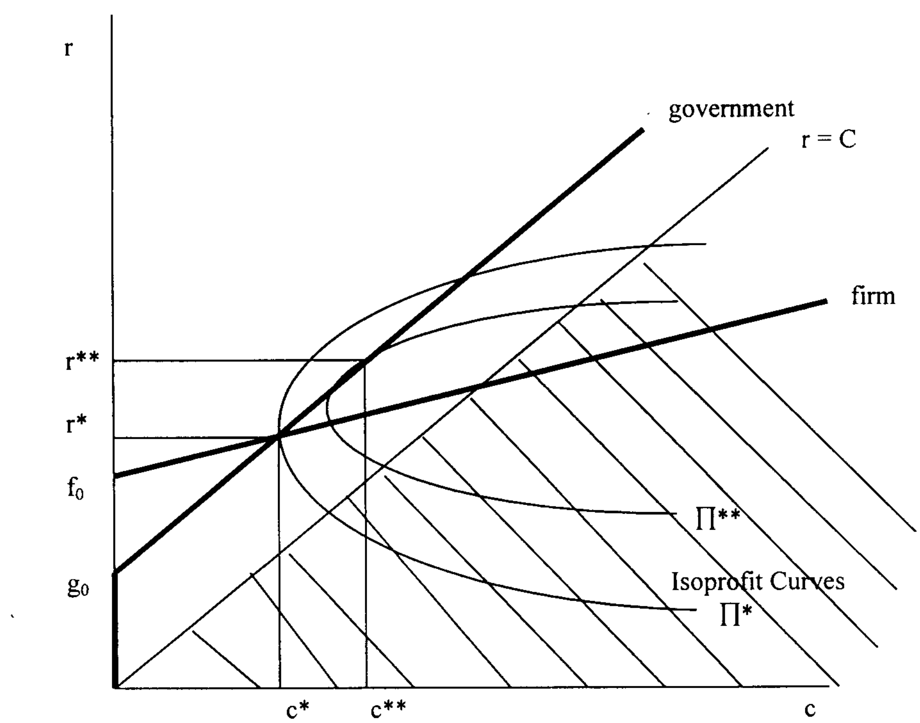
Substituting this back into the reaction function for the government given by equation [34] yields:

[57] $$C^{**} = -\frac{\beta(1+\sqrt{1+6\rho\psi\phi})}{3\rho\psi} + \frac{\delta-\alpha}{2} - \gamma\left(\frac{(1+\sqrt{1+6\rho\psi\phi})}{6\rho\psi}\right)$$

[58] $$C^{**} = \frac{\delta-\alpha}{2} - (\gamma+2\beta)\left(\frac{(1+\sqrt{1+6\rho\psi\phi})}{6\rho\psi}\right)$$

We know that if r**>r*, then C** >C* because the government's reaction function is upward sloping. The solution to the leadership game is shown graphically in Figure 3.

FIGURE 3 The Leadership Game



This figure shows that if the simultaneous game is changed to a game where the foreign firm sets it royalties before the government in the developing country sets its enforcement efforts, both royalties and concealment costs are higher. The intuition behind this finding is that the firm will maximize its profits for any given reaction function for the government. The firm could only maintain profits when moving off of its reaction function if concealment costs were to rise. This results in "c" shaped isoprofit curves with the inner curves having higher profits. In the leadership game, the firm's profits are maximized when its isoprofit curve is just tangent to the government's reaction function.

Conclusions

The introduction of the TRIPs in the Uruguay Round has provided a direct link between trade and intellectual property. Less developed countries who want to join the WTO, or simply want to continue their existing memberships, are now obligated to protect intellectual property rights or face trade sanctions.

Little research has been done to determine the impact of linking intellectual property rights in agricultural biotechnology to trade. Our analysis has provided four key findings. First, the presence of the trade penalty for infractions of intellectual property rights under the WTO will, under some circumstances, have no impact on the enforcement of these rights in developing countries. This could occur, for example, if the cost of enforcement was particularly high. Lower penalties and smaller probabilities of penalty reduce the likelihood of enforcement. Second, as the magnitude of the trade penalty increases, the cost of concealment will increase and the level of enforcement will be higher. In other words, at some point, the penalty will become large enough to encourage enforcement. Third, the only condition under which there will be no pirate production is if the trade penalty is infinitely large. Since this is not a reasonable expectation, some pirate production can always be expected. Fourth, both royalties and concealment costs are lower in the simultaneous game than in a leadership game where the firm which owns the agricultural biotechnology can commit to a royalty rate before the government of the developing country makes its enforcement decision.

These are interesting results because they suggest that the currently proposed penalty mechanism may not be effective under all circumstances. If this is the case, it may simply result in trade distortions which are completely unrelated to the original intellectual property violation. This calls into question the efficacy of linking trade penalties to the protection of intellectual property. This, in turn, makes the WTO's current strategy for protecting intellectual property seem less likely to be fully effective. Further, the developed countries which wanted the TRIPs agreement are likely to be disappointed by the small impact it has on international piracy.

We note also that our finding in regard to the probability of developing countries enforcing intellectual property rights coincides with our intuition. We would expect countries where intellectual property in agricultural biotechnology is being developed to be more enthusiastic in protecting intellectual property rights since they are the prime beneficiary of such protection. We would also expect developing countries to be more reluctant to enforce these rights since the benefits of such protection are not as clear as they are for developing countries.

The results suggest that agricultural biotechnology will receive only limited protection from piracy in developing countries under the current TRIPs arrangements. Further, as some developing countries were against the granting of intellectual property rights to agricultural crops during the Uruguay Round of negotiations, they are likely to take a minimalist approach to enforcement even if they do not attempt to exercise their right to an exemption for plants (or animals). Thus, it seems that a considerable proportion of the technological transfer to developing countries will take place through piracy rather than the market. The degree to which piracy will be the technological transfer mechanism would seem to depend much more on the ability of agricultural biotechnology firms to keep their intellectual property secret as well as the reverse engineering capability of firms in developing countries than it does on the threat of trade sanctions under the WTO.

While there may be some obvious areas where the TRIPs can be strengthened in future negotiations, it seems unlikely that agreement could be achieved to impose a sufficient penalty to reduce piracy to manageable levels. Hence, an alternative to the trade sanction based strategy for the international protection of intellectual property may have to be devised.

Endnotes

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[2]Note that the welfare function also shows another tradeoff faced by the government. If the government increases its level of enforcement to the point where it exposes piracy, it could be faced with a trade penalty. If, on the other hand, the government turns a blind eye to piracy, there is a lower probability that piracy, if it exists, will be exposed and therefore a lower probability of the developing country being faced with a trade penalty.

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