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Intellectual property rights and developing country agriculture

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Abstract

Theoretical studies indicate that the welfare of the developing countries might either be improved or damaged by the strengthening of their own intellectual property rights. Net gains through their agricultural sectors will be positive if the payoff from new innovations is sufficiently different as compared to the technology-exporting countries. Scattered evidence supports the hypotheses that agricultural R&D is responsive to IPRs in developing countries, but there is also evidence that developed-country technology is sufficiently appropriate for developing countries as to offer substantial free-rider gains. However, without IPRs it seems unlikely that the agricultural productivity rates in developing countries can begin to catch up with those in developed country agriculture.

Keywords: Intellectual property rights; Agricultural development; Technology transfer

The strength of intellectual property rights among third-world countries has become an important policy issue since the inclusion of TRIPs (trade-related intellectual property) as part of the fabric of the World Trade Organization. Such issues had traditionally been addressed through the World Intellectual Property Organization, but US frustration with attempts to strengthen the existing international treaties led also to a clause (Clause 301) in the 1988 trade act that allowed trade retaliation against countries that inadequately protect intellectual property rights. US self-interest in the issue was reflected in the US Trade Commission (1988) estimate, widely discounted, that US export losses due to intellectual property right infringements were $60 billion per year and growing.

However, the US also argued that strong intellectual property rights within developing countries would be in the self-interest of those countries themselves because of their stimulating effect on development, even though the most direct effect would be a transfer of royalty payments away from the less-developed countries. Many developing countries seem to reject this proposition, only reluctantly adopting any form of intellectual property rights because of WTO requirements. This despite the fact that developing country agricultural productivity rates are far behind those of industrialized countries (Fulginiti and Perrin, 1999). The purpose of the present paper is to consider theoretical arguments for the self-interest hypothesis as it applies to agriculture, and to summarize the little data that are relevant.

1. Intellectual property rights and appropriate technology

The potential welfare gains to developing countries (the 'South') from establishing or strengthening intel-

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lectual property rights (IPRs) has been the subject of a number of theoretical analyses over the past decade. [1] Virtually all of these studies posit a set of innovating firms and customers in the North with only customers in South. These studies almost uniformly conclude that the South would lose from strengthening their own IPRs. This result follows from the assumption in most of the studies that demanders of new innovations in the North and in the South are essentially identical. As Chin and Grossman (1990) and Deardorff (1992) both noted, under this assumption the South may benefit slightly from a larger amount of innovation that is induced by Southern IPRs, but this will be more than offset by royalty payments transferred to the North and by restricted diffusion within the South. Both Helpman (1993) and Taylor (1994) extended these static partial equilibrium studies to the case of dynamic general equilibrium, but with no change in the conclusion that the South would almost certainly lose from strengthening their own IPRs.

Diwan and Rodrik (1991) and Perrin (1994) suggested that the South might gain from stronger IPRs, however, if the payoff ranking of the various potential technologies differs between the South and North. In this case, stronger IPRs may provide an incentive for Northern innovators to choose to develop a different array of new innovations, and the rate and direction of innovation may thereby be tilted toward technology that is appropriate for the South. In agriculture, particularly, innovations are likely to be ranked differently in the South compared to the North, because of differences in the agro-climatic environment as well as relative input endowments and input prices. This source of potential gain for the South is explored further below.

Vishwasrao (1994) and Yang (1998) have offered alternative North–South models that support the possibility of Southern gains from strengthening their own IPRs. Vishwashrao considers a richer array of technology transfer mechanisms, including both royalties and licensing that include both lump-sum and per-unit payments and production by subsidiaries through direct foreign investment. His model features an asymmetric information situation in which only the South knows the level of its imitation capabilities, and he finds that the South will benefit from weak (but not strong) IPRs. Yang proposes the novel possibility that countries within the South can mutually benefit from the public good attribute of increased technology appropriate to the South, but have incentives to free-ride on the results of each other's IPR's, so there should be a welfare-increasing opportunity for coalitions to increase the strength of their IPR's simultaneously.

Diwan and Rodrik (1991) posit a model of Nash equilibrium levels of relative patent strengths in the North and South. For any period there are a large number of potential innovations, indexed by θ, of which the number actually discovered is $K = \bar{\theta} - \underline{\theta}$. One can think of K as a rate of innovation, in a dynamic context. Discoveries of these innovations are produced by a competitive industry of firms, each of which pursues a separate innovation but competes with others for scarce innovation resources, thus imparting an upward-sloping industry supply schedule for innovations, $C(K)$. Each firm faces the same known fixed cost C' of discovering its innovation. The geometric interpretation of North–South interaction that follows is consistent with the Diwan–Rodrik model and those of Deardorff (1992), and Perrin (1994).

Consumers of the innovation, who might be households or other producers or the innovating firms themselves, are differentiated with respect to willingness to pay for each innovation, designating the willingness of consumer j to pay for innovation θ_i as $D(\theta_i, j)$. Rank the consumers from high willingness to pay to low so as to produce a derived demand for diffusion of θ_i as indicated in Fig. 1. [2] Once the innovation is discovered, it is socially optimal to achieve total diffusion of the innovation (d_m in Fig. 1), since knowledge is non-rival in consumption and the costs of diffusing knowledge are negligible. The net social benefit of the technology θ_i is the sum of the consumers' willingness to pay, or the entire area under the derived demand curve of Fig. 1.

[1] Other reviews of North–South patenting issues include that of Siebeck et al. (1990), especially the chapter by Primo Braga (1990), but also see Sherwood (1990) and the collections of papers in Gadbaw and Richards (1988) and Rushing and Brown (1990), the two volumes edited by Dosi et al. (1988, 1990), and the earlier volume edited by Griliches (1984). See also the symposium papers published in the Winter, 1991, issue of Economic Perspectives.

[2] The simple diffusion/pricing model of Fig. 1, and the rate of innovation model of Fig. 3, appeared at about the same time in Deardorff (1992) and Perrin (1994).

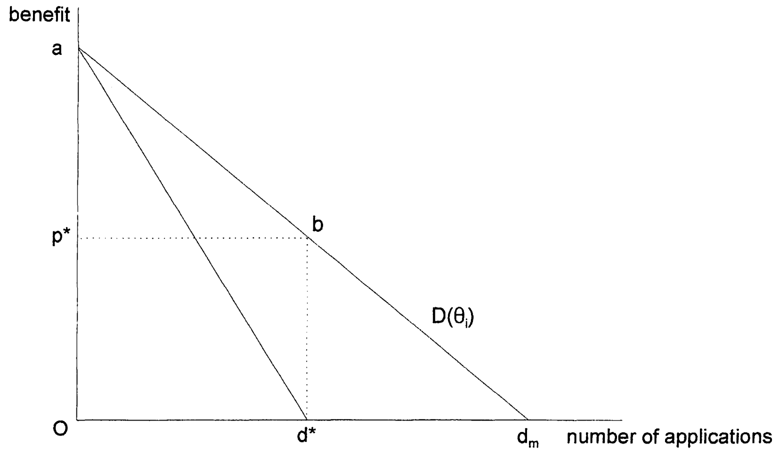

Fig. 1. The derived demand for diffusion of an innovation.

Now consider the pricing behavior of the firm that discovers and patents innovation θ_i. In the absence of the ability to price discriminate among consumers, but with patent protection that perfectly excludes all consumers from the unauthorized use of the innovation, the profit-maximizing royalty price is represented by p^*, which in turn would restrict diffusion to d^*. Now to relax the assumption of perfect patent protection, Deardorff (1992) and Perrin (1994) assume that royalties may be extracted only from some fraction of the users. Diwan and Rodrik offer an alternative approach with a similar result, that there is a limit royalty price $p=\alpha p^*$, $\alpha\in[0,1]$, above which large-scale imitation or pirating becomes feasible. Then α becomes a parameter that indexes the strength of the patent laws. For $\alpha=1$, diffusion is restricted to d^*, social benefits of diffusion of the innovation beyond d^* are foregone, and the innovating firm appropriates a substantial fraction of the benefits from the innovation (the fraction represented graphically in Fig. 1 as area Op*bd* divided by area Oabd*.) For $\alpha=0$, the innovating firm is unable to charge any price for the innovation, and while the innovation would be fully diffused to d_m, there is no longer any incentive for the innovating firm to have undertaken the innovation cost C'.

These results illustrate the fundamental policy issue related to intellectual property rights: whether it is better for the society to establish strong IPRs ($\alpha=1$) and suffer the efficiency loss associated with restricted diffusion, or to maintain weak IPRs that inhibit the number of inventions but permit wider diffusion of each. To consider this dilemma more fully, recall that there is a continuum of potential innovations such as θ_i. Considering the area under the derived demand curve for each of these innovations as the measure of its social benefit, the distribution of potential social benefits from innovation in the North, $N(\theta)$, is represented in Fig. 2. (It is convenient to speak of $N(\theta)$ as characterizing the 'tastes' of the North for various innovations, even though the innovations may be purchased by producers rather than consumers). In Fig. 2, the social optimum rate of innovation is $K_s=\bar{\theta}-\underline{\theta}$ such that the social benefits of the specific innovations indexed by $\bar{\theta}$ and $\underline{\theta}$ are just equal to the marginal innovation costs, C'. The benefits that can be appropriated by the innovating firm (its royalties) depend upon α and are some fraction of the social benefits, represented by the distribution $R_\alpha(\theta)$. The market equilibrium level of discoveries, is $K_\alpha=\bar{\theta}_\alpha-\underline{\theta}_\alpha$ such that the private royalty benefits of the innovations $\bar{\theta}_\alpha$ and $\underline{\theta}_\alpha$ are just equal to the marginal innovation costs. The area under $N_\alpha(\theta)$ between $\underline{\theta}$ and $\bar{\theta}$ represents the social benefits from innovations given patent rights of strength α, which are smaller than $N(\theta)$ because of restricted diffusion. As property rights are weakened, $\underline{\theta}$ and $\bar{\theta}$ converge toward one another and the rate of innovation falls to zero.

Fig. 3 presents an alternative representation of the social optimum and equilibrium rates of innovation. Here the potential innovations are ranked by social

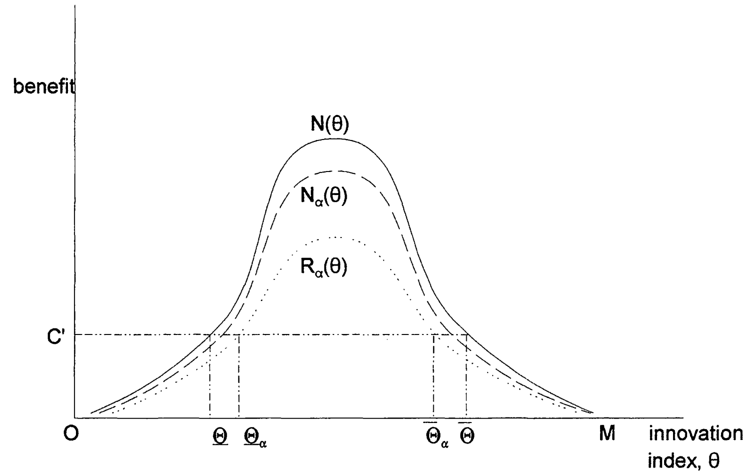

Fig. 2. Social benefits from a continuum of potential innovations.

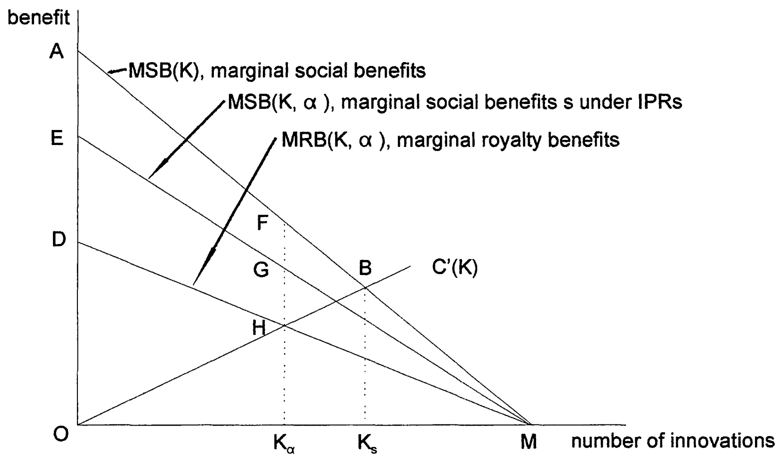

Fig. 3. Social optimum number of innovations K_s, and the market equilibrium number of innovations K_α.

benefit to form the marginal social benefit schedule MSB(K), and the social optimum K_s occurs at the point where the marginal social benefit of discovering additional innovation(s) equals the marginal social cost of discovery. (The left-to-right ordering of potential innovations in Fig. 3 corresponds to a ranking from the peak of the distribution of Fig. 2 outwards to $\underline{\theta}$ and $\bar{\theta}$.)The schedule of marginal royalty benefits (benefits appropriated by the innovators) from additional discoveries, MRB(K,α), lies below the marginal social benefits, and again the market equilibrium number of innovations discovered is K_α. Given that innovators will restrict diffusion of the innovations, marginal social benefits are reduced to MSB(K,α), line EM. Thus we have in Fig. 3 a market equilibrium in which innovators earn profits equal to area ODHO, consumers gain from innovations by area DEGH, and area EAFG represents lost efficiency from restricted diffusion of the discovered innovations. The social gain from innovation under the IPR regime is area OEGHO, compared to the social optimum level equal to area OABO. The social optimum strength of property rights, α^*, would be that level which maximizes OEGH. Perfect property rights ($\alpha = 1$) would yield the highest marginal royalty benefit function and thus the largest number of innovations K_α, but would not necessarily

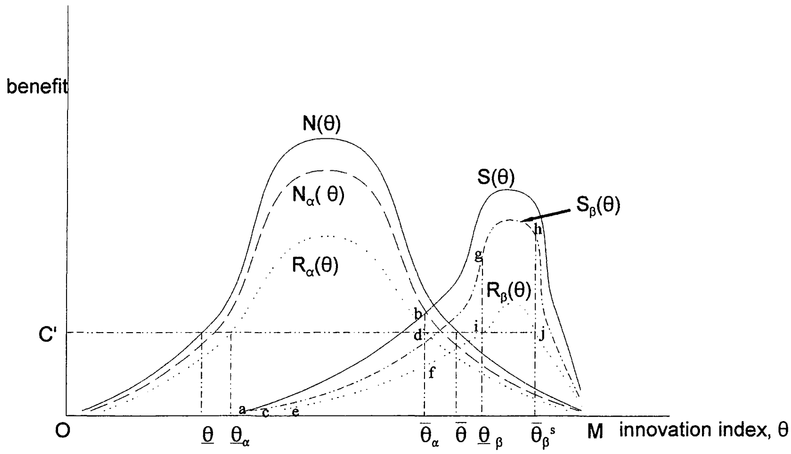

Fig. 4. Property rights and appropriate technology in the North and South.

be socially optimal because the marginal social benefit function MSB(K,α) falls with α.[3]

2. The south

Let the distribution of potential social benefits of innovation in the South be represented as $S(\theta)$, in Fig. 4. Diwan and Rodrik further suggest that benefits in the South can be conveniently calibrated relative to those in the North as $S(\theta)=\gamma N(\theta-\sigma)$, where γ indicates the relative size of the South, and s represents a horizontal shift measuring the congruity of the 'appropriateness' of innovations for the two sets of consumers. Thus if $\sigma=0$, northern technology would be fully appropriate to the South, since the order of ranking of the innovations by benefits is the same no matter which country is considered. The parameter γ shifts the height of $S(\theta)$ relative to $N(\theta)$.

The South may also choose the strength of its intellectual property rights, designated as β. If $\beta=0$, the South pays no royalties for any innovations imported from the North. All the innovations are, therefore, appropriate to the North, and gains to the South are represented by the area under the curve 'ab' in Fig. 4. Now if the South's distribution of benefits were exactly congruent with the North's, then South's gain would exceed that of the North because benefits would be equal but the South would incur no innovation costs. As the relative size of the South (γ) decreases, or the shift parameter s increases, the gains to the South from northern innovation would diminish.

If the South chooses to have property rights ($\beta>0$), the potential royalty earnings from diffusion in the South are represented by the broken line $R_\beta(\theta)$ and these earnings will enter the objective functions of the innovating firms in the North. The innovators will now receive royalties from the South as well as the North, equal to the vertical sum of $R_\alpha(\theta)$ and $R_\beta(\theta)$. A primary and significant effect of $\beta>0$ is the incentive to discover technologies that are appropriate to the South but not to the North. In Fig. 4 these technologies are represented by $\underline{\theta}_\beta^s$ to $\bar{\theta}_\beta^s$ Another effect of Southern property rights is to reduce the number of innovations appropriate to the North (if innovation costs rise) as some of those innovations are now crowded out by innovations for the South. Relative to a free-riding policy of $\beta=0$, the South now loses on its use of the North-appropriate innovations, both the royalties that it must now pay (the area below curve *ef*) and the efficiency losses from restricted diffusion (area *abdc*.) On the other hand, South gains from the increase in South-appropriate innovations (area *ghji* in Fig. 4.)

[3] The issue of optimal patent strength, determined by such parameters as the length of patent life and and the breadth of patent coverage, is analysed in a number of articles extending from Nordhaus (1969) to the symposium articles in the Spring, 1990, issue of the Rand Journal of Economics, and Gallini (1992). In the Diwan and Rodrik model, innovators are able to capture the entire consumer surplus when $\alpha=1$, which in this case is the optimal level of strength if costs are constant ($C'=0$).

It is evident that it is not necessarily in the South's self-interest to establish strong intellectual property rights, even though an increase in β tilts the range of innovations toward technology that is more appropriate for South.[4] These analyses suggest three factors that would enhance the payoff of strong IPRs in the South. First, the greater is the divergence in the distribution of payoffs from various technologies, the less appropriate is Northern technology for the South, and the greater the payoff for strong IPRs in the South. Second, the larger is the South's domain of application (γ), the greater is its payoff from IPRs (as long as the distribution of payoffs is not completely congruent with that of the North). Finally, the smaller is the share of royalty returns from a given level of property rights, the larger is the consumer share of returns, and therefore, the stronger is the incentive for the South to have strong IPRs. Before examining empirical evidence related to these issues, it is useful to list some other potential payoffs from enhanced property rights beyond those suggested by the analysis above.

2.1. Other possible IPR benefits to the south

The theory above describes how the South might benefit from stronger intellectual property rights because of a tilt of inventive activity toward more South-appropriate technology. Other possible beneficial effects that have been suggested include an advertising effect, a quality effect, a technology transfer effect and a learning effect. The advertising effect derives from the incentive for the owner of a property right to use promotion to increase the effective demand for the innovation (Burstein, 1984). In terms of Fig. 4, the effective benefit distribution curves may lie below $S(\theta)$, $S_\beta(\theta)$ and $R^s{}_\beta(\theta)$ because some of the potential beneficiaries are unaware of the innovations. Advertising shifts these effective curves upward, thus increasing returns to both consumers and innovators for any of the technologies that are adopted in the South.

The suggested quality effect of intellectual property rights in the South derives from the possibility that distributors of pirated or imitation knowledge goods may have neither the incentive nor the capability of providing quality assurance. As Evenson (1990) asserts, no technology transfer will occur without research capacity in the destination country. Distributors of pirated or imitation technology products may have less incentive to achieve repeat sales, and therefore less incentive to provide quality technology products, as compared to the technology discoverers who must plan to recover their discovery costs. Poorly reproduced agricultural chemicals, for example, may be very costly to producers (though perhaps not as costly as users of poorly reproduced airplane parts or medicines.) It is possible that because of this the Southern benefits from North-appropriate technology can be only partially realized from a free-rider status[5]: the successful introduction and supply of a new technology may require either human capital or investment capital that only property right owners have the capability to provide. In the absence of IPRs within the South, innovators from the North will have no incentive to provide this input, and the technology may not be imported despite the option to free-ride.

An additional indirect effect to be considered is the possible learning effect. The argument is that because property rights will stimulate diffusion, human capital of the indigenous population should increase also, thus increasing the South's capacity to generate and utilize additional innovations.

3. Empirical evidence on property rights and developing agriculture

Very little empirical evidence is available about the economic effects of intellectual property rights, especially as they pertain to agriculture and developing countries. Dramatic changes in IPR regimes have occurred hardly at all until recent changes induced by WTO pressures. Lesser's (Lesser, 1997) informative summary identifies only one study examining the effects of a change in patent policy in a developing

[4] Diwan and Rodrik explore the reaction function of the South, whose property rights strength is β, relative to North's α. In their model as in the case here, optimal β is certainly positive if $\alpha = 0$ because there would otherwise be no innovation at all for South to use.

[5] A closely related technology transfer effect of IPRs has also been suggested See Sherwood (1990), p. 124, 162, Frischtak (1990) and Pray (1987).

country, that by Deolalikar and Evenson (1990) that examines the effects of India's weakening of industrial patent protection in 1970. The authors attribute a substantial reduction in Indian pharmaceutical R&D to the reduction in property rights, but technology import effects were not identified. Sherwood (1990) cites anecdotal and survey evidence from Mexico and Brazil to conclude (p. 152) that while much of the effect of weak property rights is invisible, their influence on innovation is more than just marginal. Frischtak (1990) offers corroborating survey evidence for the case of Brazil. While these last two studies did not focus on agriculture, they did include responses from firms in the food and chemicals industries.

Apart from abrupt changes in IPR regimes, the strength of IPRs varies through time and across countries, but is difficult to measure, since it is determined by a wide range of features such as the number of years the rights are valid, the 'breadth' of the ideas and activities that are excludable, the extent of the enabling disclosures, and the cost of enforcing the rights. Gould and Gruben (1996), however, obtained an index of the strength of property rights across 95 countries, and regressed 1960–1988 GDP growth rates on this index and other variables. They found significant effects, with estimated elasticity of growth rate with respect to IPR strength ranging from 0.4 to 1.0. The subjectivity of the IPR index make these results difficult to interpret, but they are consistent with the notion that IPRs are useful for developing countries, and no other econometric results relevant to the issue seem to exist.

Changes in plant breeders' rights in various countries have provided a social experiment useful in the analysis of the effects of property rights. Before and after studies of the US plant variety protection act suggest that it had a significant effect on private R&D and on the number of varieties commercially available, but the productivity effects have not yet been established (Perrin et al., 1983; Butler and Marion, 1985). Pray and Echeverria (1991) found evidence of an R&D effect of plant breeders rights in Chile, but neither they nor Jaffe and Van Wijk (1995) found evidence of any effect in Argentina (where enforcement has not been consistent). Some indirect evidence supporting the effectiveness of IPRs in plant breeding is the widespread private R&D investment in hybrid corn and sorghum as contrasted with other crops. De facto property rights have always existed for hybrids because by keeping parental lines secret, the breeder can exlude users who do not buy his seed each year (hybrids do not self-reproduce as do the varieties used for seeds for most other field crops). Private-sector plant breeding activity for these crops is indicated by the fact that their share of the maize seed market is about 60% in Asia and North Africa, and even higher in other regions that include LDCs (Echeverria, 1991) Thus the evidence from plant breeders rights studies suggests that appropriability does have a stimulating effect on R&D activity and technology transfer in agriculture, though IPR legislation itself may not ensure that appropriability ensues.

Evenson and Binswanger (1978) addressed the question of spillover benefits of agricultural research from one country to another. They examined cereal grain research among countries within each of Papadakis' 34 geoclimatic regions, and found that developing countries with no indigenous research capacity would receive little spillover benefits, whereas those with average levels of research capacity would receive spillover benefits comparable to the benefits in the innovating country. The econometric results were not very robust, but they nonetheless suggest that free-rider benefits can be substantial, minimizing the incentives for Southern countries in close agro-climatic proximity to the North to strengthen property rights in the crops research area.

4. Concluding comment

It is not evident that agricultural development in the South would benefit from stronger intellectual property rights, despite the tendency of strong IPRs to tilt innovation toward technology that is appropriate for the South. For a given less-developed country, the 'appropriate technology' case for strong IPRs increases with the size of the agricultural sector and increases with the divergence of its agro-climatic characteristics from those of the North. The potential agricultural development benefits from IPRs as opposed to free-rider status include not only the direct benefits of increased innovation of 'appropriate' technology, but the potential effects of increased promotional activities, better quality of technology goods transferred from the North, and the domestic learning effect from the increased cooperation.

Anecdotal and statistical evidence confirms significant effects of IPRs on innovative activity in both the North and the South. But the costs of strengthening IPRs, such as increased royalty payments and public administrative expenditures, are more evident than the benefits, leading to a bias against adopting or strengthening them. In any case, the size of 'pirate gains' (royalty fees that are avoided by a free-riding non-IPR country) may in itself be a poor measure of the net impact of enforcing IPRs in that country.

Agriculture in the less developed countries has not been successful in closing the productivity gap relative to the North. One significant feature that may contribute to the gap is the lack of vitality of the private agricultural input sector in the South. The weakness of IPRs in the South cannot be totally responsible for this lack of vitality, but there is no doubt about their qualitative effect. Meanwhile as the debate about the strength of IPRs continues, the state of the arts in agriculture seems poised for another spurt forward, based on new technologies springing from the techniques and knowledge of molecular biology. If countries of the South do not experiment with strengthened IPRs as a means of bringing more private innovative activity into the effort to capitalize on this new technology, it seems inescapable that the productivity gap will continue to widen.

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References

Burstein, M.L., 1984. Diffusion of knowledge-based products: applications to developing countries. Econ. Inquiry 22, 608–633.

Butler, L.J., Marion, B.W., 1985. Impacts of patent protection in the US seed industry and public plant breeding. North Central Regional Research Bulletin No.304, University of Wisconsin, Madison, WI.

Chin, J.C. Grossman, G.M., 1990. Intellectual property rights and north-south trade. In: Jones, R.W., Krueger, A.O. (Eds.), The Political Economy of International Trade: Essays in Honor of Robert E. Baldwin, Basil Blackwell, Cambridge, MA.

Deardorff, A.V., 1992. Welfare effects of global patent protection. Economica 59, 35–51.

Deolalikar, A.B., Evenson, R.E., 1990. Private inventive activity in Indian manufacturing: its extent and determinants. In: Evenson, R.E., Rains, G.,(Eds.), Science and Technology: Lessons for Development Policy, Westview, Boulder CO.

Diwan, I., Rodrik, D., 1991. Patents, appropriate technology and North-South trade. J. Int. Econ. 30, 27–47.

Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L., (Eds.), 1988. Technical Change and Economic Theory. Pinter Publishers, London.

Dosi, G., Pavitt, N., Soete, L., 1990. The Economics of Technical Change and International Trade. Harvester Wheat Sheaf Publishers, London.

Echeverria, R.G., 1991. Impact of research and seed trade on maize productivity. In: Pardey, P.G., Roseboom, J.,Anderson, J.R. (Eds), Agricultural Research Policy: International Quantitative Perspectives. Cambridge University Press, Cambridge.

Evenson, R.E., 1990. Intellectual property rights, R&D, inventions, technology purchase, and piracy in economic development. In: Evenson.R.E., Ranis, G. (Eds), Science and Technology: Lessons for Development Policy. Westview, Boulder, CO.

Evenson, R.E. Binswanger, H.P., 1978. Technology transfer and research resource allocation. In: Binswanger, H.P., Ruttan, V.W. (Eds.), Induced Innovation: Technology, Institutions and Development, Johns Hopkins U. Press, Baltimore.

Frischtak, C.,1990. The protection of intellectual property rights and industrial technology development in Brazil. In: Rushing, F.W., Brown, C.G. (Eds), Intellectual Property Rights in Science, Technology, and Economic Performance. Westview, Boulder CO.

Fulginiti, L.E., Perrin, R.K., 1999. Have price policies damaged LDC agricultural productivity? Contemporary Economic Policy, forthcoming.

Gadbaw, R.M., Richards, T.J., (Eds), 1988. Intellectual Property Rights: Global Consensus, Global Conflict? Westview, Boulder, CO.

Gallini, N.T., 1992. Patent policy and imitation. Rand J. Econ. 23, 52–63.

Gould, D.M., Gruben, W.C., 1996. The role of intellectual property rights in economic growth. J. Develop. Econ. 48, 323–350.

Griliches, Z., (Ed.), 1984. R&D, Patents and Productivity. University of Chicago Press, Chicago.

Helpman, E., 1993. Innovation, imitation and intellectual property rights. Econometrica 61, 1247–1280.

Jaffe, W., Van Wijk, J., 1995. The inpact of plant breeders' rights in developing countries. Inter-American Institute for Cooperation on Agriculture, University of Amsterdam.

Lesser, W., 1997. Assessing the implications of intellectual property rights on plant and animal agriculture. Am. J. Agric. Econ. 79, 1584–1591.

Nordhaus, W.D., 1969. Invention, Growth and Welfare. MIT Press, Cambridge, MA.

Perrin, R.K., 1994. Intellectual property pights in agricultural development. In anderson, J.R., (Ed), Agricultural Technology: Policy Issues for the International Community. CAB International, Wallingford.

Perrin, R.K., Hunnings, K.A., Ihnen, L.A., 1983. Some effects of the US plant variety protection act of 1970. Economics Research Report No. 46, Dept. of Economics and Business, N.C. State University, Raleigh.

Pray, C.E.,1987. Private sector agricultural research in Asia. In: Ruttan, V.W., Pray, C.E. (Eds), Policy for Agricultural Research. Westview, Boulder, CO.

Pray, C.E., Echeverria, R.G., 1991. Private-sector agricultural research in less-developed countries. In: Pardey, P.G., Roseboom, J., Aanderson, J.R., (Eds.), Agricultural Research Policy: International Quantitative Perspectives. Cambridge University Press, Cambridge.

Primo Braga, C.A., 1990. Guidance from economic theory. In: Siebeck, W.E., Evenson, R.E., Lesser, W., Primo Braga, C.A., (Eds.), Strengthening Protection of Intellectual Property in Developing Countries: A Survey of the Literature. World Bank Discussion Paper No 112, Washington.

Rushing, F.W., Brown, C.G., (Eds.), 1990. Intellectual Property Rights in Science, Technology, and Economic Performance. Westview Press, Boulder, CO.

Siebeck, W.E., Evenson, R.E., Lesser, W., Primo Braga, C.A., (Eds.), 1990. Strengthening Protection of Intellectual Property in Developing Countries: A Survey of the Literature, World Bank Discussion Paper 112, Washington.

Sherwood, R.M., 1990. Intellectual Property and Economic Development. Westview Press, Boulder, CO.

Taylor, M.S., 1994. Trips, trade, and growth. Int. Econ. Rev. 35, 361–381.

Vishwasrao, S., 1994. Intellectual property rights and the mode of technology transfer. J. Develop. Econ. 44, 381–402.

Yang, Y., 1998. Why do southern counhtries have little incentive to protect northern intellectual property rights? Can. J. Econ. 31, 800–816.