ELSEVIER

Journal of Development Economics 78 (2005) 474–493

JOURNAL OF Development ECONOMICS

www.elsevier.com/locate/econbase

Intellectual property rights and innovation in developing countries

Yongmin Chen [a,*], Thitima Puttitanun [a,b]

[a]*Department of Economics, University of Colorado at Boulder, Boulder, CO 80309, United States*
[b]*Department of Economics, San Diego State University, United States*

Received 1 June 2002; accepted 1 November 2004

Abstract

This paper studies intellectual property rights (IPRs) and innovation in developing countries. A model is developed to illustrate the trade-off between imitating foreign technologies and encouraging domestic innovation in a developing country's choice of IPRs. It is shown that innovations in a developing country increase in its IPRs, and a country's IPRs can depend on its level of development non-monotonically, first decreasing and then increasing. Empirical analysis, with a panel of data for 64 developing countries, confirms both the positive impact of IPRs on innovations in developing countries and the presence of a U-shaped relationship between IPRs and economic development.

JEL classification: O31; O34; O1
Keywords: Intellectual property rights; Innovation; Economic development

1. Introduction

The protection of intellectual property rights (IPRs) in developing countries has been a much debated issue in recent years. This debate is often placed in a North–South framework, where the predominant view is that southern (developing) countries tend to lose from protecting IPRs. The static and partial equilibrium reason for this loss is that

* Corresponding author. Tel.: +1 303 492 8736; fax: +1 303 492 8960.
E-mail address: Yongmin.chen@colorado.edu (Y. Chen).

doi:10.1016/j.jdeveco.2004.11.005

IPRs protection will strengthen the market power of northern innovating firms and raise prices in developing countries (Chin and Grossman, 1990; Deardorff, 1992).[1] But even when dynamic and general equilibrium factors are accounted for, the South need not benefit from increasing IPRs, partly due to the adverse terms-of-trade effect and the possible slowing down of northern innovations over time (Helpman, 1993). In fact, Helpman concludes:

> "Who benefits from tight intellectual property rights in less developed countries? My analysis suggests that if anyone benefits, it is not the South." (Helpman, 1993, pp. 1274)

There are, however, several arguments of why developing countries need to increase their protections of IPRs. First, as Diwan and Rodrik (1991) argue, northern and southern countries generally have different technology needs and, without the southern protection of IPRs, northern countries would not develop technologies largely needed by the South. Second, northern firms may react to the lack of IPRs in the South by making their technologies more difficult to imitate, which can result in less efficient research technology and less northern innovation (Taylor, 1993, 1994; Yang and Maskus, 2001). Third, even if greater protection of IPRs does not directly benefit the South, it could still increase world welfare; therefore, there are gains from international cooperation that tightens IPRs in developing countries. In fact, issues on trade-related intellectual property rights (TRIPS) have been a key element in the WTO negotiations, and strengthening of IPRs is often a condition for a developing country's entry to the WTO (Maskus, 2000). Importantly, even these arguments for strong southern IPRs seem to suggest that, were it not for strategic reactions or pressures from the North, the southern developing countries would have little incentive to protect IPRs.[2]

This paper offers an alternative perspective on the protection of IPRs in developing countries. We shall argue that even if strategic behavior of or pressures from the North is not a concern, a developing country may still want to protect IPRs, for domestic economic considerations. In particular, there may be domestic innovative activities that would rise under stronger IPRs. For such an economy, there could be an optimal level of IPRs, which balances the trade-off between facilitating the imitation of northern advanced technologies and providing incentives for domestic innovations. To motivate this approach, we note that while most innovations originate from the North, there are substantial innovative activities in many developing countries, as measured by patent applications filed in these countries by domestic inventors.[3] For instance, during 1985–

[1] According to Primo Braga et al. (2000), this view was widely accepted among policy-makers in the 1970s. It was believed that since developing countries had little ability to create intellectual property, they had little to gain from IPRs that would mainly grant monopolies to foreign patentees.

[2] Zigic (1998, 2000) contain interesting models in which strategic considerations by northern firms can provide incentives for the South to increase IPRs.

[3] The innovative activities we have in mind are much broader than those that can be protected through patents. In fact, activities such as developing a new product that may be granted a trademark or a copyright could be very important for a developing country. The advantage of focusing on patent applications is that there are data on them, which is important for our empirical analysis.

1995, the number of such applications was 2757 in Brazil, 1545 in India, 5549 in South Africa, and 59,249 in South Korea; as compared to 9325 in Australia, 3039 in Canada, 335,061 in Japan, and 127,476 in the US during the same period. Furthermore, although collectively IPRs in the South can significantly affect northern innovation incentives, the effect of a single developing country may be negligible, as has been noticed by Yang (1998); and such a country may take the northern innovation as exogenous.

We consider a model of a (small) developing country that has two sectors, an import sector and a local sector. The import sector consists of a (northern) foreign firm and a domestic firm. The foreign firm has a patented technology that allows it to produce a product of a higher quality than can be produced by the domestic firm. However, the domestic firm can raise its product quality by imitating the northern technology, and its ability to do so depends on the level of IPRs in this country. The local sector consists of two domestic firms, one of which has the ability to develop a patentable new technology that improves the product quality, while the other local firm can imitate the new technology. Increased protection of IPRs makes imitation in both sectors more difficult, which has different effects on the country's welfare. In the import sector, less imitation means lower product quality of the domestic firm and thus less competition for and higher price of the foreign firm. As a result, there is a reduction of consumer surplus and (domestic) social surplus. In the local sector, less imitation means more incentive for the domestic innovating firm to invest in a higher-quality technology (more innovation), which leads to more efficient investment and to a higher social surplus. In a game where the government first chooses the level of IPRs, followed by investment of the domestic innovating firm and then by production in both sectors, we show that the optimal protection of IPRs balances this basic trade-off. In equilibrium, the incentive to innovate by the domestic firm increases with IPRs protection. Furthermore, there exist plausible situations where, starting from a low level of development, increases in the level of development lower IPRs initially but raise IPRs after a certain point. Thus, a developing country's preferred levels of IPRs can exhibit a U-shaped curve with respect to its levels of economic development, given the advanced technologies of the North.

The possible existence of an empirical U-shaped curve between IPRs and per capita GNP has been noticed by Maskus (2000) and by Primo Braga et al. (2000). However, to the best of our knowledge, ours is the first formal model that provides a theoretical explanation for such a (possible) empirical relationship. Starting from low levels of economic development, an initial increase in a country's technological ability has a greater impact on the efficiency of imitating northern technologies than on the efficiency of domestic innovations, which makes it desirable for the country to lower IPRs. Once the country's technological ability is above a certain threshold, the imitation effect is dominated by the innovation effect, and the optimal protection of IPRs increases with the levels of development.[4]

[4] Our results are related to the findings in Acemoglu et al. (2002): Countries at early stages of development benefit from strategies that encourage technology adoption, while countries closer to the world technology frontier benefit from switching to strategies that encourage innovation.

While it is important to develop new theoretical insights, it is also interesting to know whether the theoretical possibilities suggested by our model are supported by empirical evidence. To investigate this we use a panel of data for developing countries that provide measures of IPRs and innovation. Our empirical analysis departs from the literature in several respects. First, other empirical studies on the relationship between IPRs and innovations/growth, including Deolalikar and Lars-Hendrik (1989), Gould and Gruben (1997), Lach (1995), Park and Ginarte (1997), Thompson and Rushing (1996, 1999), Maskus and McDaniel (1999) and Crosby (2000), have mostly focused on developed countries or pooled data on both developed and developing countries. Our analysis provides new evidence on developing countries. Second, while there are notable exceptions, such as Ginarte and Park (1997), Maskus (2000), and Maskus and Penubarti (1995), most existing studies have taken IPRs as exogenous. As our theoretical analysis shows, a rational developing country will choose an optimal level of IPRs, depending on its level of economic development. We thus treat IPRs as endogenous. Consistent with our theoretical predictions, we find some evidence that innovations in developing countries are indeed positively and significantly impacted by IPRs, and the levels of IPRs exhibit a U-shaped relationship with per capita GDP.

The rest of the paper is organized as follows. Section 2 illustrates our main idea through a simple model and derives our theoretical implications. Section 3 discusses our data and conducts the empirical analysis. Concluding remarks are contained in Section 4.

2. A model of optimal IPRS

A developing country can choose its protection of IPRs, $\beta \in [0; 1]$; where a higher β indicates a higher level of protection, with $\beta = 0$ indicating no protection and $\beta = 1$ indicating perfect protection.[5] To parameterize the model, let $\theta \in (0; 1]$ be a measure of the country's level of development or technological ability, with a higher θ indicating a higher development level. The country has two sectors, A and B, the import and the local sector respectively.[6] In sector A, a (northern) foreign firm, denoted by F, sells a product of quality u^F under certain patented technology. A domestic firm, D, may also engage in the production in A, whose product quality is $u^D(\beta,0) = u_0 + u^F \phi(\theta)\ [1 - \alpha(\beta)]$, where, $\forall \theta$, $0 \leq \phi(\theta) \leq 1$, $\phi'(\theta) > 0$, $\alpha(\beta) \geq 0$, $\alpha'(\beta) > 0$, $\alpha(1) = 1$, and $0 \leq u_0 \leq u^F\ (1 - \phi(1))$. Thus, the imitation ability of D, measured by $\phi(\theta)$, is higher if θ is higher, D cannot imitate F's technology if there is perfect protection for IPRs; and D's quality improvement from

[5] While the level of IPRs in our model might be thought of as patent breadth, in the tradition of the industrial organization literature (see, e.g., O'Donoghue et al., 1998); we choose to interpret β more broadly, as a measure of overall protection of IPRs, which also depends on factors such as the enforcement of patent laws and protections of not patented IPRs (such as trade secrets and trade marks).

[6] We assume that the same β applies to both sectors; a government cannot selectively enforce IPRs protection. This may be because if the government does not protect IPRs in one sector, it will also have difficulty protecting IPRs in the other sector, perhaps because its actions influence people's expectations about what are acceptable social behaviors. Our result will extend to situations where there can be different β's in different sectors, as long as these β's are positively correlated.

imitation is higher when protection for IPRs is lower. Moreover, even with no IPRs protection, D may not be able to achieve the same technological level as F. There is a continuum of consumers of measure 1 in A. Each consumer in A assigns a value to one unit of the product that is equal to its quality, but has zero valuation for any additional unit. All firms in A have constant unit cost $c^{A} \in [0, u_0]$.

Sector B also has two firms, L and M, both of which are domestic firms. Firm L's product has quality $v\ (z;\ \theta)$; where $z \geq 0$ is L's investment in quality improvement, and $\forall\theta$, $v_z(z, \theta) > 0$, $v_z(\infty, \theta) = 0$, $v_{zz}(z, \theta) < 0$, $v_\theta(z, \theta) > 0$, and $v_{z\theta}(z;\ \theta) > 0$.[7] Firm M can also produce in B, with product quality $v^{M}(\beta;\ \theta) = v(z;\ \theta) - \gamma(\beta)\ (v(z;\ \theta) - v_0)$; where, $\forall\theta$, $0 \leq v_0$, $\gamma(0) > (1/v_z(0,\theta))$, $\gamma'(\beta) > 0$, and $\gamma(1) = 1$: Without further loss of generality, we let $v_0 \equiv 0$ and thus $v^{M}(\beta;\ \theta) = v(z;\ \theta)\ (1 - \gamma(\beta))$. There is a continuum of consumers of measure $N > 0$ in sector B. Each consumer in B assigns a value to one unit of the product that is equal to its quality, but has zero valuation for any additional unit. All firms in B have constant unit cost $c^{B} \equiv 0$.

The formulation above assumes that consumers have identical preferences; namely, the representative consumer's utility from consuming a product from either A or B has the form

$$U = \mu - p,$$

where μ is the quality of the good and p its price. This follows the literature on innovation, imitation and IPRs in the framework of quality ladders and product cycles (e.g., Grossman and Helpman, 1991; Helpman, 1993; and Yang and Maskus, 2001), though we do not consider product cycles. The advantage of this formulation, as it shall become immediately clear, is that all consumers will purchase from the high-quality firm in equilibrium, and the equilibrium price is easy to compute. It is possible to extend our model to allow for heterogeneous consumer preferences, as in the framework of vertical product differentiation. We shall return to this below.

The game is as follows: The government first chooses β, the level of IPRs protection. Firm L then chooses z, its expenditures on R&D (or, equivalently, the level of innovation). The product qualities of all firms are then determined. The game then moves to the price-competition stage, where firms F and D simultaneously choose prices for their products in market A and firms L and M simultaneously choose prices for their products in market B. Afterwards, possible purchases are made by consumers and production is carried out.

We solve the subgame perfect equilibrium of the game through the usual method of backward induction. Given any β and any $z > 0$, there is a unique Nash equilibrium in each sector at the price-competition stage where the equilibrium prices of firms F, D, L, and M are, respectively:

$$p^{F} = c^{A} - u_0 + u^{F}[1 - \phi(\theta)[1 - \alpha(\beta)]], \quad p^{D} = c^{A}; \tag{1}$$

$$p^{L} = c^{B} + \gamma(\beta;\theta)v(z;\ \theta), \quad p^{M} = c^{B}, \tag{2}$$

and all consumers purchase from F in A and purchase from L in B.

[7] Notice that since an increase in z leads to a quality improvement in L's product, z represents both an investment (expenditure) in quality improvement and a measure of the domestic innovation.

We next determine the equilibrium choice of z by L, $z\ (\beta;\ \theta)$. Notice that the profit of L is

$$\pi^{\mathrm{L}} = N\left[\left(c^{\mathrm{B}} + \gamma(\beta)v(z;\ \theta)\right) - c^{\mathrm{B}}\right] - z = N\gamma(\beta)v(z;\ \theta) - z.$$

The optimal $z\ (\beta;\ \theta)$ thus satisfies

$$N_{\gamma}(\beta)v_z(z(\beta;\ \theta);\ \theta) \leq 1,\ \text{where the equality holds if } z(\beta;\ \theta) > 0. \tag{3}$$

Since $\gamma(0) > (1/v_z(0;\ \theta))$ by assumption; we have $\gamma(0)v_z(0;\ \theta) > 1$. Hence $z(\beta;\ \theta) > 0$ and condition (3) holds in equality. Since $v_{zz}(z;\ \theta) < 0$ and $v_z(\infty;\ \theta) = 0$, $z(\beta;\ \theta)$ exists uniquely.

By the implicit differentiation rule,

$$z_{\beta}(\beta;\ \theta) = -\frac{\gamma'(\beta)v_z(z(\beta;\ \theta);\ \theta)}{\gamma(\beta)v_{zz}(z(\beta;\ \theta);\ \theta)} > 0.$$

$$z_{\theta}(\beta;\ \theta) = -\frac{v_{z\theta}(z(\beta;\ \theta);\ \theta)}{v_{zz}(z(\beta;\ \theta);\ \theta)} > 0.$$

We have thus shown:

Proposition 1. *Given any $\beta \in [0;\ 1]$, $z\ (\beta;\ \theta)$ uniquely solves*

$$N_{\gamma}(\beta;\ \theta)v_z(z(\beta;\ \theta);\theta) = 1. \tag{4}$$

Furthermore, $z(\beta;\ \theta) > 0$, $z_{\beta}(\beta;\ \theta) > 0$, and $z_{\theta}(\beta;\ \theta) > 0$.

Thus, how L would invest in quality improvement depends both on its efficiency in quality improvement (θ) and on the competitor's ability to imitate, the latter of which depends on β. In particular, a higher β results in L's choosing a higher z.

The government's objective is assumed to choose β that maximizes (domestic) social surplus:

$$\begin{aligned} W(\beta) &= u^{\mathrm{F}} - \left(c^{\mathrm{A}} - u_0 + u^{\mathrm{F}}[1 - \phi(\theta)[1 - \alpha(\beta)]]\right) + N\left(v(z(\beta;\ \theta);\ \theta) - c^{\mathrm{B}}\right) \\ &\quad - z(\beta;\ \theta) \\ &= u^{\mathrm{F}}\phi(\theta)[1 - \alpha(\beta)] - c^{\mathrm{A}} + u_0 + Nv(z(\beta;\ \theta);\ \theta) - z(\beta;\ \theta), \end{aligned}$$

subject to the constraint that $0 \leq \beta \leq 1$ (recall that $c^{\mathrm{B}} = 0$ by assumption).

For any given θ, let the optimal choice of β be $\beta(\theta)$. Then, from the Kuhn–Tucker first-order condition, we have:

$$[Nv_z(z(\beta(\theta);\ \theta);\ \theta) - 1]z_{\beta}(\beta(\theta);\ \theta) - u^{\mathrm{F}}\phi(\theta)\alpha'(\beta(\theta))\begin{cases} \leq 0 & \text{if} \quad \beta(\theta) < 1 \\ \geq 0 & \text{if} \quad \beta(\theta) > 0 \end{cases},$$

where $0 < \beta(\theta) < 1$ if

$$u^{\mathrm{F}}\phi(\theta)\alpha'(\beta(\theta)) = [Nv_z(z(\beta(\theta);\ \theta);\ \theta) - 1]z_{\beta}(\beta(\theta);\ \theta),$$

and the left and right hand sides of the equation immediately above are respectively the marginal cost and benefit of increasing β. Moreover, since $\beta(\theta)$ maximizes $W(\beta)$, if $\beta(\theta)$ is unique and interior, it must be true (from the second-order condition) that

$$\frac{\partial\left([Nv_z(z(\beta(\theta);\ \theta);\ \theta)-1]z_\beta(\beta(\theta);\ \theta)-u^{\mathrm{F}}\phi(\theta)\alpha'(\beta(\theta))\right)}{\partial\beta}<0,$$

and therefore $\beta'(\theta)$ has the same sign as

$$\frac{\partial\left([Nv_z(z(\beta(\theta);\ \theta);\ \theta)-1]z_\beta(\beta(\theta);\ \theta)-u^{\mathrm{F}}\phi(\theta)\alpha'(\beta(\theta))\right)}{\partial\theta}$$

$$=[Nv_z(z(\beta(\theta);\ \theta);\ \theta)-1]z_{\beta\theta}(\beta(\theta);\ \theta)-u^{\mathrm{F}}\phi'(\theta)\alpha'(\beta(\theta)).$$

That is,

$$\beta'(\theta)\begin{cases}>0 & \text{if } u^{\mathrm{F}}\phi'(\theta)\alpha'(\beta(\theta))<[Nv_z(z(\beta(\theta);\ \theta);\ \theta)-1]z_{\beta\theta}(\beta(\theta);\ \theta)\\ <0 & \text{if } u^{\mathrm{F}}\phi'(\theta)\alpha'(\beta(\theta))<[Nv_z(z(\beta(\theta);\ \theta);\ \theta)-1]z_{\beta\theta}(\beta(\theta);\ \theta)\end{cases}.$$

Notice that $u^{\mathrm{F}}\phi'(\theta)\alpha'(\beta(\theta))$ is the effect of an increase in θ on the marginal cost of increasing β, and $[Nv_z(z(\beta(\theta);\theta);\theta)-1]\ z_{\beta\theta}(\beta(\theta);\theta)$ is the effect of an increase in θ on the marginal benefit of increasing β. We thus have:

Proposition 2. *Suppose that the optimal level of IPRs, $\beta\ (\theta)$, is unique and $0<\beta(\theta)<1$. Then:*
(i) $\beta\ (\theta)$ satisfies

$$u^F\phi(\theta)\alpha'(\beta(\theta))=[Nv_z(z(\beta(\theta);\ \theta);\ \theta)-1]z_\beta(\beta(\theta);\ \theta)\,. \tag{5}$$

That is, the marginal benefit and marginal cost of increasing β are equalized:
(ii) $\beta'(\theta)\gtrless 0$ if

$$u^F\phi'(\theta)\alpha'(\beta(\theta))\lessgtr[Nv_z(z(\beta(\theta);\ \theta);\ \theta)-1]z_{\beta\theta}(\beta(\theta);\ \theta)\,. \tag{6}$$

That is, $\beta\ (\theta)$ is increasing (decreasing) if the effect of an increase in β on the marginal cost of increasing β is lower (higher) than that on the marginal benefit of increasing β.

An increase in β affects W through the two terms in Eq. (5). The term on the left side represents the reduction in consumer surplus in A. A higher β makes it more difficult for a domestic firm to imitate the more advanced foreign firm's technology, reducing the competition for and raising the equilibrium price of the foreign firm: This effect reduces W. The term on the right side represents the net benefit from quality improvement by firm L in B due to the increase in β, which is welfare improving. The choice of $\beta(\theta)$ balances this trade off.

To see how $\beta(\theta)$ will behave, we can consider $u^{\mathrm{F}}\phi'(\theta)\alpha'(\beta(\theta))$ in condition (6) as the imitation effect of increasing θ. A higher θ makes an increase in β more costly in sector A, since the potential benefit of imitation in A is higher. On the other hand,

$$[Nv_z(z(\beta(\theta);\ \theta);\ \theta)-1]z_{\beta\theta}(\beta(\theta);\ \theta)$$

measures the innovation effect of increasing θ in Sector B: A higher θ increases $v_z(z(\beta(\theta);\theta);\theta)$ and $z_\beta(\beta(\theta);\theta)$, which makes it more desirable to increase β. Starting from low levels of θ, an increase in θ is likely to have a greater impact on the benefits from imitating foreign technologies than the benefits from increasing domestic innovations, and it is thus likely that the imitation effect dominates the innovation effect (Recall that $v_{z\theta}(z;\ \theta)>0$). When θ is above a certain level, the efficiency of domestic innovation can be high enough such that the innovation effect dominates. It is thus possible that $\beta(\theta)$ first decreases and then increases, as can be seen from the following example:

Example. Assume $\alpha(\beta)=1+\ln[(1+\beta)/2]$, $\gamma(\beta)=(1+\beta)/2$, $u^{\mathrm{F}}=1$, $u_0=0$, $\phi(\theta)=(1/3)(1+2\theta)$, $v(z;\ \theta)=2\ln[(1+z)/(1-\theta)]$, $N=1$, and $\theta\in(0,\ 1]$. All of our assumptions are satisfied. We have: $v_z(z;\ \theta)=2[1/(1-\theta)][1/(1+z)]$, $\alpha'(\beta)=1/(1+\beta)$. From $\gamma(\beta)v_z(z\ (\beta);\ \theta)=1$; we obtain

$$z(\beta;\ \theta)=\frac{\beta+\theta}{1-\theta},\quad z_\beta(\beta;\ \theta)=\frac{1}{1-\theta}.$$

From $u^{\mathrm{F}}\phi'(\theta)\alpha'(\beta^*)=[Nv_z(z(\beta^*;\ \theta);\ \theta)-1]z_\beta(\beta^*;\ \theta)$; we have

$$\frac{1}{3}(1+2\theta)\frac{1}{1+\beta}=\left(2\frac{1}{1-\theta}\frac{1}{1+\dfrac{\beta+\theta}{1-\theta}}-1\right)\frac{1}{1-\theta},$$

$$\beta(\theta)=\frac{2}{3}\theta^2-\frac{1}{3}\theta+\frac{2}{3}.$$

The $\beta(\theta)$ is U-shaped here, decreasing for $\theta<1/4$ and increasing for $\theta>1/4$. Fig. 1 shows the curve of $\beta(\theta)$ from this example.

Remark 1. Under certain parameter values, there exists some $\theta_1\in(0,1)$ such that $\beta'(\theta)<0$ if $\theta<\theta_1$ and $\beta'(\theta)>0$ if $\theta>\theta_1$. That is, as θ rises, the optimal level of IPRs first decreases and then increases.

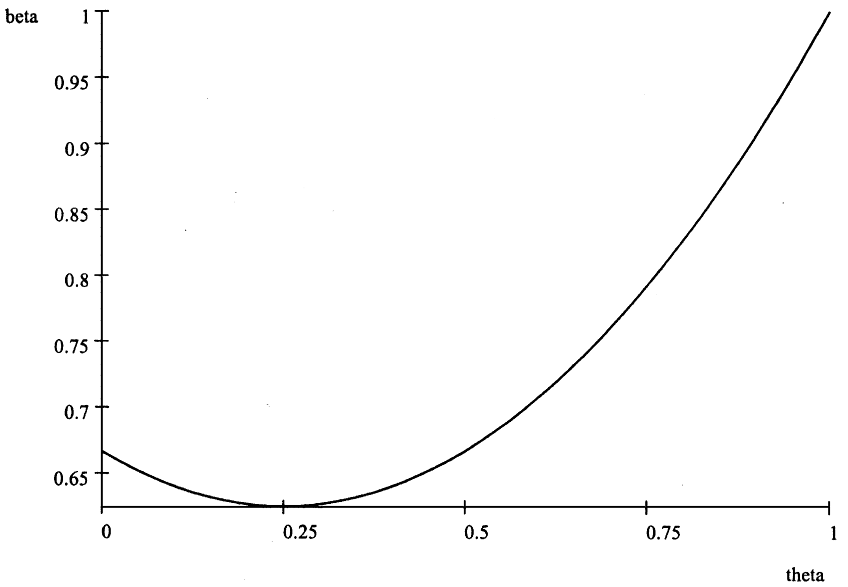

Fig. 1. Relationship between $\beta(\theta)$ and θ.

In constructing our theoretical model, we have placed great emphasis on making the model transparent and sharpening the trade-off that is the focus of our analysis. The model can be extended in many directions without changing the basic insight. For instance, our results would not change if there were more than one imitating domestic firm in sector A and/or in sector B; or if there were several local sectors. If the innovations were cost reducing process innovations instead of product innovations and the foreign firm has a better technology that gives it a cost advantage in the import sector, our results would be essentially the same.

Our assumption that consumers have identical quality preferences makes the exposition more straightforward but is not crucial for the insight of the paper. Suppose instead that consumers have different preferences for quality. For instance, suppose that $U = h\mu - p$, where h is a taste parameter uniformly distributed across the consumer population on some interval $[\underline{h}, \bar{h}]$ for $\underline{h} \geq 0$. Then, as long as the range of $[\underline{h}, \bar{h}]$ is sufficiently narrow, in equilibrium all consumers will purchase from the high-quality firm,[8] and the essence of our results will not change. However, if the range of $[\underline{h}, \bar{h}]$ (consumer heterogeneity) is large enough, in each sector consumers with higher quality taste would purchase from the high-quality firm while consumers with lower taste would purchase from the low-quality firm. In this case, it is possible that each firm's profit is higher with increased differentials in the two firms' product qualities (see, for instance, page 296–297 of Tirole, 1989). This means that the low-quality firm will not imitate the high-quality firm and no IPRs violation would be observed in equilibrium (and hence IPRs policy would be irrelevant). While this possibility might be interesting in itself, we focus on the cases where firms do have incentives to imitate and IPRs are relevant. If we include in our model additional industries where IPRs are irrelevant, the overall nature of our results about the effects and optimal choice of IPRs for an economy would not change, since optimal choice of IPRs will be based on the effects in the industries where they are relevant.

Our analysis would essentially be the same if sector A has more general demand functions instead of the unit demand; but having more general demand functions in sector B would complicate the analysis somewhat, since a higher β will then have the usual effect of encouraging innovation but reducing static efficiency (higher deadweight loss after product quality is determined) in B. However, the basic trade-off between increasing the foreign firm's market power and increasing the domestic firm's innovation incentives would remain the same if more general demand functions are introduced in B. The advantage of assuming unit demand is that higher β will always unambiguously increase social surplus in B; allowing us to sharpen the basic trade-off that is the focus of our analysis.

Our theoretical model yields two testable implications:

1. Domestic innovations in a country increase in its protection of IPRs (i.e., $z_\beta(\beta;\, \theta) > 0$) and with its level of development (i.e., $z_\theta(\beta;\, \theta) > 0$).

[8] And, again, there is effective competition in each sector from the presence of another firm.

2. It is possible that a country's level of IPRs first decreases and then increases in its level of development.

We next study the empirical evidence on these two implications.

3. Empirical analysis

In this section, we first describe the data, then discuss the econometric model and finally present the results.

3.1. Data

The data come from various sources. Most of the data come from the World Development Indicators CD-ROM and Statistical Yearbook by UNESCO (UNESCO, 1995, 1997, 2000). Patent data come from the United States Patent and Trademark Office website.

To measure IPRs (β), we use the GP index, a commonly used measurement of intellectual property rights protection developed by Park and Ginarte (1997). They examined the patent laws of a comprehensive number of countries, considering five components of the laws: duration of protection, extent of coverage, membership in international patent agreements, provisions for loss of protection, and enforcement measures. The index scale ranges from 0 to 5, with higher numbers reflecting stronger levels of protection.[9] Since it is a quinquennially index, we have collected the other variables in this study in every 5 years for the 1975–2000 period. Due to the limited data access, 64 developing countries are included in the sample, 16 of which are considered Middle-Income countries. Table A1 in Appendix A lists the names of these 64 countries.

There are two widely used measures of innovation. One is R&D expenditures, which measure the input of innovation. The other is the number of patent applications and/or patents granted, which measures inventive output. Since data on R&D expenditures are not available for most developing countries, we use the number of patent applications filed at the U.S. patent office by developing countries residents[10] as our measure of innovations by domestic firms (z), denoted by IN.[11]

To measure the level of technological ability or development (θ), we use per capita GDP, denoted by GDPCAP. The data on per capita GDP in 1995 US dollars come from World Development Statistics CD-ROM.

[9] Since the index is bounded from zero to five, there could be a concern regarding the truncation of the data. However, in our data set, there is no observation on the boundary (IPRs index = 0 or 5). It thus does not appear that there is a serious truncation problem for our date set.

[10] Details of this data is available at the U.S. Patent and Trademark Office: http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_all.pdf.

[11] Patent applications filed by residents in their own country are not an appropriate measure in our context, since, even if the real innovative activities have not changed, increasing IPRs in a country can lead to more patenting in that country. Patent applications in the US is a proper measure since the US patent system can be viewed as exogenous to any developing country.

Table 1
Descriptive statistics

Variable	No. of observations	Mean	S.D.	Min.	Max.
IN	267	155.105	947.245	0	14,045
IPRs	370	2.437	0.710	0.33	4.19
GDPCAP	368	2881.434	4063.536	56.496	28,461.93
EDU	309	11.817	11.266	0.3	77.621
TRADE	367	69.108	55.254	5	439.029
POP	370	37,300	107,000	344	1,020,000
EF	350	5.473	1.176	2.3	9.06

We have also obtained data on several other variables that may affect innovations and/or IPRs. We have data on measures of economic freedom, EF, from www.freetheworld.com. The freedom index ranges from 0 to 10, with a higher index indicating a higher level of economic freedom (see Gwartney et al., 2003 for details). To measure the education variable, EDU, we use the percentage of the total enrollment among the school-age population at the tertiary level. These ratios are collected from various issues of Statistical Yearbook by UNESCO and from the World Development Indicators CD-ROM. We also have data on the population of a country, POP (the unit is thousands of people), to measure the size effect. International trade volume as a percentage of GDP is denoted as TRADE and is used as a measure of trade openness of a country. Descriptive statistics are shown in Table 1.

Since one of our main interests is the relationship between IPRs and economic development, it is useful to have a simple graph about this relationship before we formally

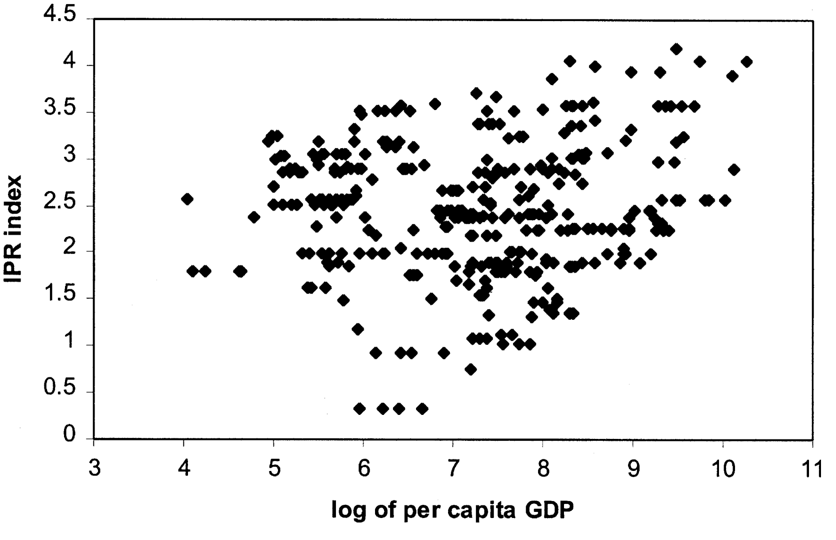

Fig. 2. A scatter plot of the relationship between IPRs and per capita GDP.

develop our empirical analysis. Fig. 2 plots this relationship using our data set. As in Maskus (2000), this relationship appears to be non-linear.

3.2. Model specification

The empirical model is a system of two simultaneous equations, one for IPRs protection and one for domestic innovation. The system can be expressed as:

$$\text{IPRs} = f(\text{GDPCAP};\ \text{GDPCAPSQ};\ \text{EDU};\ \text{TRADE};\ \text{EF};\ \text{WTO}) \qquad \text{(i)}$$

$$\text{IN} = f(\text{IPRs};\ \text{GDPCAP};\ \text{EDU};\ \text{EF};\ \text{POP}) \qquad \text{(ii)}$$

where, in addition to the variables explained earlier, we have included GDPCAPSQ, the square of GDPCAP; and WTO, the dummy variable for WTO membership. Since only Eq. (ii) contains an endogenous variable (IPRs) on the right-hand side, the model is a triangular simultaneous equation system.[12]

For Eq. (i), the first two variables, GDPCAP and GDPCAPSQ, correspond to θ and θ^2 in our theoretical model. Since our theory predicts the possibility of $\beta(\theta)$ having a U shape, this suggests that GDPCAP and GDPCAPSQ should have negative and positive effects, respectively. EF is expected to have a positive effect, since part of this index represents protection of private property. For TRADE, there can be arguments both for a positive and for a negative effect. The more open to trade a country is, one may argue, the more it will be influenced to have higher IPRs. On the other hand, more TRADE could imply that a country is more exposed to advanced foreign technology, and thus domestic firms can benefit more from imitation, suggesting lower IPRs. Membership of the WTO is expected to have a positive effect since TRIPS[13] requires WTO members to increase their IPRs standards. The effect of EDU would be positive, if a more educated society has more respect for knowledge and thus for IPRs. To eliminate any country specific effect or unobserved heterogeneity we use least squares on first-differenced data.[14] White's test suggests heteroskedasticity in this equation, so we use Huber/White/Sandwich robust standard errors (White, 1980). Serial correlation tests did not indicate any problem.

For Eq. (ii), our theory suggests that IPRs and GDPCAP should have positive effects. We also expect POP to have a positive effect, because of the scale effect on innovation. EF and EDU will also have positive effects, if economic freedom and education encourage innovation. Since the right-hand side of Eq. (ii) includes an endogenous variable (IPRs), two stage least squares is used.[15] This involves getting the predicted

[12] Admittedly, it is restrictive to assume that other variables on the right-hand sides are exogenous. The formulation here is based on several considerations, including the implications of our theoretical model, the exclusion requirement, the availability of data, and other recent studies that have considered similar exogenous variables in explaining IPRs (e.g., Ginarte and Park, 1997; Maskus, 2000).

[13] Trade Related Intellectual Property Rights (TRIPS) is a proposal on IPRs under the General Agreement on Tariffs and Trade (GATT) in the Uruguay Round of Multilateral Trade Negotiations.

[14] OLS regression on the first-differenced transformed data yields unbiased estimates of the coefficients on the right hand side variables (Johnston and DiNardo, 1997).

[15] Endogeneity is a problem only if the errors in Eqs. (i) and (ii) are correlated. If they are not, the system is recursive and OLS is the effcient estimator.

Table 2
IPRs regression ($n=211$)

Variables	Model 1: without time dummies	Model 2: with time dummies
GDPCAP	−0.269* (0.114)	−0.218** (0.115)
GDPCAPSQ	0.024* (0.009)	0.019* (0.009)
EDU	0.022 (0.028)	0.007 (0.033)
EF	0.135 (0.100)	0.111 (0.106)
TRADE	−0.042 (0.030)	−0.045 (0.030)
WTO	0.110* (0.046)	0.101 (0.095)
1985 dummy	–	−0.002 (0.015)
1990 dummy	–	−0.008 (0.023)
1995 dummy	–	0.011 (0.087)
2000 dummy	–	0.121 (0.092)

Estimated coefficients are shown together with the standard errors in parentheses. *, ** Denote 5% and 6% levels of significance respectively. All variables are in log format except the WTO and time dummy variables.

values of IPRs from a first stage regression on all the exogenous variables, and then using the predicted values in the second stage regression, adjusting the standard errors appropriately. Since the number of patent applications ranges from 0 to 14045 with the mean being 155, it can be properly treated as a continuous variable.[16] Again we first-difference the data to eliminate the country specific effect[17] (fixed effects regressions are strictly speaking not appropriate due to the presence of an endogenous variable on the right-hand side), and since the White test indicates heteroskedasticity we use robust standard errors. Serial correlation tests again did not indicate any problem.

To account for possible regime changes of IPRs over time that are not related to the explanatory variables we estimate both equations in two models: Model 1 contains no time dummies and Model 2 contains time dummies.

3.3. Statistical results

We report the results for Eq. (i) in Table 2 and the results for Eq. (ii) in Table 3. All variables are in log except WTO and the time dummies; standard errors of coefficients are listed in parentheses.

From Table 2, GDPCAP and GDPCAPSQ have the signs that confirm the U-shaped relationship between GDPCAP and IPRs in both models. This suggests that countries tend to lower their IPRs initially as GDPCAP begins to rise and then raise them after a certain point. In Model 1 (column 2 of Table 2), the curve reaches its minimum at

[16] This treatment has also been used in other studies, such as Kortum and Lerner (1998). Without treating IN as a continuous variable, we would need to use the GMM method in estimating the model. In addition to being a significantly more complex procedure, the GMM method may also be more susceptible to bias in the estimation due to the relatively small size of our sample (we have only 218 total observations for Eq. (ii)).

[17] We also estimate both (i) and (ii) without country dummies and report the level estimates of these regressions in Tables A2 and A3 of Appendix A.

Table 3
IN regression ($n = 154$)

Variables	Model 1	Model 2	Model 3	Model 4
IPRs	9.787* (4.029)	3.407*** (2.226)	5.752** (3.406)	1.280 (1.278)
GDPCAP	2.512** (1.406)	0.558 (0.434)	2.248* (0.699)	0.418* (0.191)
EDU	1.847* (0.678)	0.015 (0.209)	1.760* (0.549)	−0.020 (0.391)
EF	−0.733 (1.413)	−0.338 (0.501)	−0.296 (1.179)	−0.200 (0.391)
POP	28.952* (1.766)	0.549 (1.930)	29.336* (1.527)	1.150 (1.548)
IPRs*GDPCAP	–	–	29.494* (13.877)	17.874* (7.204)
1985 dummy	–	4.222* (0.251)	–	4.161* (0.204)
1990 dummy	–	8.396* (0.581)	–	8.259* (0.477)
1995 dummy	–	12.320* (0.821)	–	12.139* (0.667)
2000 dummy	–	16.607* (1.123)	–	16.425* (0.905)

Estimated coefficients are shown together with the standard errors in parentheses. The standard errors shown in the table are already corrected for the two stage least square estimations. *, ** and *** denote 5%, 10%, and 12% levels of significance respectively. All variables are in log transformation except the time dummy variables.

around log(GDP per capita) = 6.75, which translates into a per capita GDP of US$854.06 in 1995 prices. This GDP per capita level is well below the mean of our data set, suggesting that for many developing countries, increases in GDP per capita increase IPRs. Both economic freedom and education have positive effects but are insignificant, similar to Park and Ginarte (1997) and Maskus (2000). The TRADE variable also shows no significant effect on the IPRs of these developing countries. The WTO variable has a significant positive effect when the time dummies are not included. In Model 2 (column 3 of Table 2), we further see that time dummies are not individually significant and that the effects of other variables are similar, except that WTO is no longer significant.

Table 3 reports the results for domestic innovation, measured by patent applications filed in the U.S. by residents of that country.[18] Model 1 (column 2) has no time dummies and Model 2 (column 3) has time dummies. Both the levels of IPRs and of development (GDPCAP) have positive and significant impact on domestic innovation in Model 1 but development is insignificant in Model 2. EDU has a positive impact on innovation in Model 1 but becomes insignificant after adding time dummy variables. EF has no detectable impact on IN in both models. The effect of POP in both models is positive but significant only in Model 1. Moreover, all the coefficients for the time dummies are positive and significant in Model 2, suggesting a general increase in innovation in developing countries over time.[19]

[18] The first stage regression partialled on the included right hand side variables are reported in Table A4 in Appendix A. The F-test indicates that the excluded variables (GDPCAPSQ, TRADE, WTO) are jointly significant ($F = 4.94$, p-value = 0.0025).

[19] To address the concern that some exogenous variables may in fact be endogenous, which can cause bias in our estimation, we also estimated both models in both equations with Arellano–Bond GMM. Our results on the key relationships (the U-shaped curve and the positive impacts of IPRs on innovation) are qualitatively unchanged, except that all right-hand side variables become insignificant in Model 2 of Eq. (i).

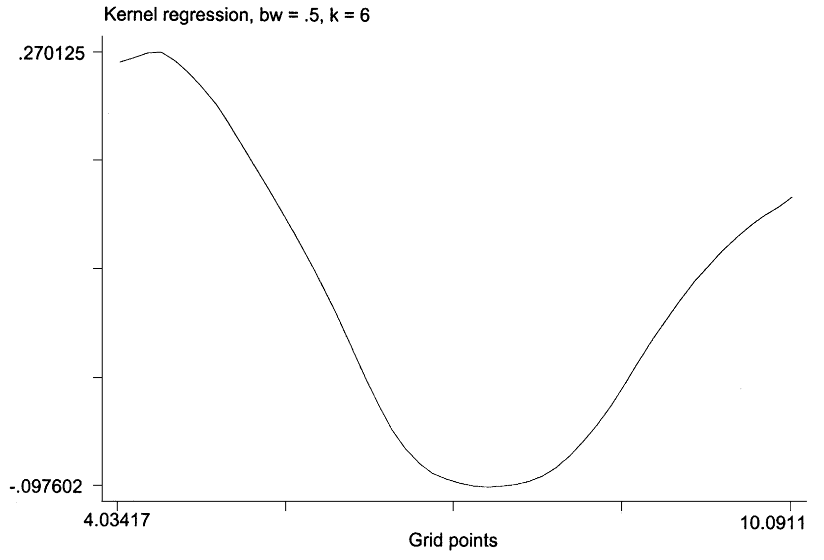

Fig. 3. Semiparametric estimates of the effect of GDP per capita on IPRs.

In the example of our theoretical model, since $z_\beta(\beta;\,\theta)=1/(1-\theta)$, we have

$$z_{\beta\theta}(\beta,\theta)=\frac{1}{(1-\theta)^2}.$$

This suggests that the positive impact of IPRs on innovation may increase with θ; or economic development. To test this possibility, we add an interaction term between IPRs and GDPCAP to both Model 1 and Model 2,[20] obtaining Model 3 and Model 4 respectively. Columns 4 and 5 of Table 3 report the results. Interestingly, the interactive term indeed has a positive and significant impact on IN, suggesting that increasing IPRs has a greater impact on innovations in countries with higher levels of economic development. The impacts of other variables in models 3 and 4 are qualitatively similar to those in models 1 and 2, respectively, except that, in Model 4, while the impact of IPRs remains positive, it is no longer significant by itself.

We have also estimated Eqs. (i) and (ii) without eliminating the country-specific effects (without country dummies). The results of these level estimates regressions are reported in Tables A2 and A3 of Appendix A. The U-shaped relationship between IPRs and GDPCAP still exists. Furthermore, the impacts of IPRs and GDPCAP on IN continue to be positive and significant in models 1 and 2; but they are no longer significant in models 3 and 4, where the interactive term between IPRs and GDPCAP is added.

[20] To generate the interaction term between IPRs and GDPCAP, we use the first stage predicted IPRs (in log) multiplied by the log of per capita GDP.

Since a key finding here is the U-shaped relationship between IPRs and GDP per capita, we are interested in how robust this result is.[21] An alternative approach is to perform a nonparametric regression estimation, in which the data is given flexibility to characterize its own shape of curvature. This flexible approach can provide remarkably accurate estimates when the underlying regression function is quite nonlinear (Lee, 1996; DiNardo and Tobias, 2001). While we are interested in the possible relationship between IPRs and GDP per capita, IPRs also depend on other variables, as can be seen from Table 2. It is therefore desirable to separate the effects of these other variables. However, there is a computational problem to include many variables in a nonparametric regression. One way to combat this problem is to use semiparametric analysis, in which we remain nonparametric about the key variable of interest (GDP per capita), but take a parametric stance about other variables. Using the Guassian kernel function, a semiparametric estimate of the effect of GDP per capita on IPRs, controlling for other variables, is shown in Fig. 3. As we can see from Fig. 3, this relationship between GDP per capita and IPRs indeed appears to be U-shaped.

The empirical results support the implications of our theoretical model: $z_\beta(\beta;\ \theta)>0$; $z_\theta(\beta;\ \theta)>0$; and $\beta\ (\theta)$ is U-shaped, confirming that the imitation effect indeed dominates when θ is relatively low but is dominated by the innovation effect when θ is above a certain level. This threshold level corresponds to a per capita GDP of about US$854 in 1995 prices.

4. Conclusion

This paper has conducted a theoretical and empirical analysis of intellectual property rights and innovation in developing countries. While lower IPRs facilitate imitations of foreign technologies, which reduces the market power of foreign firms and benefits domestic consumers, a developing country may also need to increase IPRs in order to encourage innovations by domestic firms. We show that innovation in a developing country increases with the protection of IPRs, and it is possible that a country's optimal IPRs depend on its level of development (technological ability) in a non-monotonic way, first decreasing and then increasing. We evaluate these theoretical results empirically, using a panel data set including 64 developing countries over the 1975–2000 period. The empirical evidence confirms both the positive impact of IPRs on innovations in developing countries and the presence of a U-shaped relationship between IPRs and levels of economic development.

[21] To address the possible concern that countries who were colonized might be responsible for the U-shaped relationship, we created a dummy variable to control for countries that were once colonized by Britain or France and estimated the same simultaneous equations with the addition of the colony dummy variable and the interaction terms between colony dummy and per capita GDP. The U-shaped relationship, as well as the other main empirical relations reported, is found to be robust with respect to this modified specification.

The conventional wisdom on IPRs has been that a developing country tends to lose from increasing IPRs and, if it does increase its protection for IPRs, it is due to pressures from the developed world. In other words, if there is a trade off for a developing country in its choice of IPRs, it is largely the need to gain access to foreign technologies/markets against the benefits from imitation. In this paper, we have focused on a different trade-off: the need to facilitate imitation and the need to provide incentives for domestic innovation. We believe that the benefits from IPRs to a developing country are actually much more than encouraging domestic innovation in the narrow sense. As Stiglitz (1989) has suggested, the lack of a functioning market system could be the biggest obstacle to the development of an economy. The respect for property rights in general, and for IPRs in particular, can be crucial for the establishment of a well-functioning market system and can thus be crucial to economic development.[22] The positive effects of IPRs on domestic innovations, therefore, should be viewed as part of broader effects on entrepreneurial activities.[23] Our analysis suggests a range of common interests between the North and the South in promoting IPRs in the South. This is not to say that there exists no conflict in their interests; in fact, our theory suggests that there could be less incentive to protect IPRs for countries with lower innovative abilities (lower levels of development). But as more developing countries recognize the importance of encouraging entrepreneurial (innovative) activities by domestic firms, the range of common interests between developing and developed countries in promoting IPRs will broaden. Thus, in the long-run, perhaps the best way for the North to promote IPRs in the South is to help the South increase innovative activities.

Acknowledgements

We thank four referees, Editor Pranab Bardhan, Philippe Aghion, Eric Brunner, Catalina Amuedo Dorantes, Keith Maskus, Terra McKinnish, Robert McNown, Kusum Mundra, Carlos Primo Braga, Lars-Hendrik Roller, Ron Smith, Randy Walsh, Don Waldman, and participants at the World Bank's 14th Annual Bank Conference on Development Economics, the WZB conference on "Innovation Policy in International Markets", the IOS's 1st Annual International Industrial Organization Conference, and a seminar at the Hong Kong University of Science and Technology for helpful comments and suggestions. Financial support from the National Science Foundation under grant #9911229 is gratefully acknowledged. We are solely responsible for errors or opinions expressed.

[22] This is consistent with the view that property rights are important in providing investment incentives and, more generally, the preconditions for economic growth. See Besley (1995).

[23] Again, our view is that the government is unable to establish and enforce two entirely different system of property rights in two different sectors. If property rights are not respected and protected in one sector, it would be extremely difficult, if not impossible, to convince entrepreneurs in the other sector that their property rights will be effectively protected.

Appendix A

Table A1
Developing countries included in the data set[a]

Algeria	India	The Philippines
Argentina	Indonesia	Portugal
Bangladesh	Iran	Rwanda
Bolivia	Israel	Sierra Leone
Botswana	Jamaica	Singapore
Brazil	Jordan	Somalia
Burundi	Kenya	South Africa
Chile	Madagascar	South Korea
Colombia	Malaysia	Sri Lanka
Costa Rica	Malawi	Syria
Cyprus	Mali	Tanzania
Dominican Republic	Malta	Thailand
Ecuador	Mauritius	Trinidad and Tobago
Egypt	Mexico	Tunisia
El Salvador	Morocco	Turkey
Fiji	Nepal	Uganda
Ghana	Nicaragua	Uruguay
Greece	Nigeria	Venezuela
Guatemala	Pakistan	Zambia
Haiti	Panama	Zimbabwe
Honduras	Paraguay	
HongKong	Peru	

[a] Based on the classification in World Investment Report 1995, UN and the selections in Maskus (2000).

Table A2
Level estimates without country dummies for Eq. (i)

(Log IPRs as a dependent variable)		
Variables	Model 1	Model 2
Constant	2.618* (0.465)	2.558* (0.457)
GDPCAP	−0.560* (0.131)	−0.539* (0.127)
GDPCAPSQ	0.043* (0.009)	0.043* (0.008)
EDU	−0.081* (0.024)	−0.100* (0.025)
EF	−0.244 (0.159)	−0.277 (0.158)
TRADE	0.106* (0.035)	0.099 (0.035)
WTO	0.288* (0.051)	−0.049 (0.127)
1985 dummy	–	0.041 (0.127)
1990 dummy	–	0.046 (0.058)
1995 dummy	–	0.286* (0.132)
2000 dummy	–	0.489* (0.128)

Estimated coefficients are shown together with the standard errors in parentheses. * Denotes 5% level of significance. All variables are in log format except the WTO and time dummy variables. Both models were tested for heteroskedasticity and use robust standard errors.

Table A3
Level estimates without country dummies for Eq. (ii)

Variables	Model 1	Model 2	Model 3	Model 4
Constant	−20.954* (1.388)	−23.337* (2.375)	−19.754* (2.232)	−22.239* (3.272)
IPRs	2.259* (0.596)	4.446* (1.533)	0.992 (2.137)	3.288 (3.081)
GDPCAP	1.015* (0.104)	0.676* (0.193)	0.861* (0.285)	0.558 (0.401)
EDU	0.264* (0.122)	0.637* (0.261)	0.256* (0.103)	0.616* (0.210)
EF	0.324 (0.426)	1.343* (0.657)	0.305 (0.371)	1.297* (0.560)
POP	0.782* (0.056)	0.851* (0.084)	0.783* (0.048)	0.849* (0.068)
IPRs × GDPCAP	–	–	0.169 (0.304)	0.143 (0.414)
1985 dummy	–	−0.202 (0.315)	–	−0.204 (0.262)
1990 dummy	–	−0.226 (0.335)	–	−0.221 (0.277)
1995 dummy	–	−1.156* (0.552)	–	−1.123* (0.449)
2000 dummy	–	−1.764* (0.807)	–	−1.713* (0.665)

Estimated coefficients are shown together with the standard errors in parentheses. * Denotes 5% level of significance. The standard errors are already corrected for the two stage least square estimations. All variables are in log format except the WTO and time dummy variables. All models were tested for heteroskedasticity and use robust standard errors.

Table A4
First stage regression for Eq. (ii)

(Log IPRs as a dependent variable)		
Variables	Models 1 and 3	Models 2 and 4
GDPCAP	−0.272* (0.115)	−0.214** (0.115)
GDPCAPSQ	0.024* (0.010)	0.019* (0.009)
EDU	0.017 (0.031)	0.007 (0.033)
EF	0.133 (0.101)	0.110 (0.106)
TRADE	−0.042 (0.030)	−0.044 (0.029)
POP	0.038 (0.087)	−0.048 (0.128)
WTO	0.108* (0.046)	0.099 (0.095)
1985 dummy	–	0.003 (0.020)
1990 dummy	–	0.002 (0.037)
1995 dummy	–	0.027 (0.100)
2000 dummy	–	0.141 (0.111)
n	211	211

Estimated coefficients are shown together with the standard errors in parentheses. * and ** denote 5% and 6% levels of significance. All variables are in log format except WTO and time dummy variables.

Reference

Acemoglu, D., Aghion, P., Zilibotti, F., 2002. Distance to Frontier, Selection, and Economic Growth. NBER Working Paper No. w9066.

Besley, T., 1995. Property rights and investment incentives: theory and evidence from Ghana. Journal of Political Economy 103, 903–937.

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

Crosby, M., 2000. Patents, innovation and growth. Economic Record 76, 255–262.

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

Deolalikar, A., Lars-Hendrik, R., 1989. Patenting by manufacturing firms in India: its production and impact. Journal of Industrial Economics 37, 303–314.
Diwan, I., Rodrik, D., 1991. Patents, appropriate technology, and North–South trade. Journal of International Economics 30, 27–48.
DiNardo, J., Tobias, J., 2001. Nonparametric density and regression estimation. Journal of Economic Perspectives 15, 11–28.
Ginarte, J.C., Park, W.G., 1997. Determinants of patent rights: a cross-national study. Research Policy 26, 283–301.
Gould, D., Gruben, W., 1997. The role of intellectual property rights in economic growth. In: Dev Gupta, Satya, Choudhry, Nanda K. (Eds.), Dynamics of Globalization and Development. Kluwer Academic Publishers.
Grossman, G., Helpman, E., 1991. Quality ladders and product cycles. Quarterly Journal of Economics, 557–586.
Gwartney, J., Lawson, R., Emerick, N., 2003. Economic Freedom of the World: 2003 Annual Report, The Fraser Institute.
Helpman, E., 1993. Innovation, imitation, and intellectual property rights. Econometrica 61, 1247–1280.
Johnston, J., DiNardo, J., 1997. Econometric Methods. McGraw Hill, New York.
Kortum, S., Lerner, J,. 1998. Does venture capital spur innovation? NBER working paper no. 6846.
Lach, S., 1995. Patents and productivity growth at the industry level: a first look. Economics Letters 49, 101–108.
Lee, M.-J., 1996. Methods of Moments and Semiparametric Econometrics for Limited Dependent Variable Models. Springer, New York.
Maskus, K.E., 2000. Intellectual Property Rights in the Global Economy. Institute for International Economics, Washington, DC.
Maskus, K.E., McDaniel, C., 1999. Impacts of the Japanese patent system on productivity growth. Japan and the World Economy 11, 557–574.
Maskus, K.E., Penubarti, M., 1995. How trade-related are intellectual property rights? Journal of International Economics 39, 227–248.
O'Donoghue, T., Scotchmer, S., Thisse, J.-F., 1998. Patent breadth, patent life, and the pace of technological progress. Journal of Economics and Management Strategy 7, 1–32.
Park, W.G., Ginarte, J.C., 1997. Intellectual property rights and economic growth. Contemporary Economic Policy 15, 51–61.
Primo Braga, C., Fink, C., Paz Sepulveda, C., 2000. Intellectual property rights and economic development. World Bank Discussion Papers, 412.
Stiglitz, J.E., 1989. Markets, market failures, and development. The American Economic Review 79, 197–203.
Taylor, M.S., 1993. TRIPS, trade, and technology transfer. Canadian Journal of Economics 26, 625–637.
Taylor, M.S., 1994. TRIPS, trade, and growth. International Economic Review 35, 361–381.
Thompson, M.A., Rushing, F., 1996. An empirical analysis of the impact of patent protection on economic growth. Journal of Economic Development 21, 61–79.
Thompson, M.A., Rushing, F., 1999. An empirical analysis of the impact of patent protection on economic growth: an extension. Journal of Economic Development 24, 67–76.
Tirole, J., 1989. The Theory of Industrial Organization. MIT Press, Cambridge.
UNESCO: Statistical Yearbook 1995, 1997, and 2000.
White, H., 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. Econometrica 48, 817–838.
Yang, Y., 1998. Why do southern countries have little incentive to protect Northern intellectual property rights? Canadian Journal of Economics 31, 800–816.
Yang, G., Maskus, K.E., 2001. Intellectual property rights, licensing, and innovation in an endogenous product cycle model. Journal of International Economics 53, 169–187.
Zigic, K., 1998. Intellectual property rights violations and spillovers in North–South trade. European Economic Review 42, 1779–1799.
Zigic, K., 2000. Strategic trade policy, intellectual property rights protection, and North–South trade. Journal of Development Economics 61, 27–60.