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Abstract

Very little empirical evidence exists on the relationship between intellectual property rights and innovation. Existing studies tend to be indirect and do not consider the influence of IPRs on innovation per se; nor do they adequately allow for the endogeneity of IPRs. Correcting for these omissions, we show that the strength of intellectual property protection has a strong positive influence on innovation.

Keywords: Innovation, IPRs, Endogeneity.

JEL Classification: O 34; O 31.

1. Introduction

The fact that governments, corporate bodies, and advocacy groups spanning the developing and developed worlds argued bitterly for more than eight years before the Trade-Related Intellectual Property Rights (TRIPs) agreement was finally signed in 1994 reflects, inter alia, the need for more persuasive evidence than is currently available, on the (presumed) causality running from intellectual property rights (IPRs) to innovation. Ex-ante several possibilities arise. First, strengthening IPRs all-round could lead to greater innovation in developed countries (Segerstrom 1991; Levin et.al. 1987) which, in turn, could be helpful for developing countries. Often, though, developed country innovations are inappropriate for developing countries. Second, strengthening protection could lead to greater innovation in developing countries as well, if only by ensuring foreign direct investment and technology transfer from the North to the South (Taylor 1993, 1994). Third, strengthening protection may not spur innovation significantly, and may well hamper it by constraining knowledge flows – due to inadequate disclosure of the innovation in the patent application, the accumulation of sleeping patents, or the inhibition of imitation (Bessen and Maskin 2000; Gilbert and Newbery 1982; Roffe 1974). It was precisely these concerns that the prolonged negotiations for the TRIPs agreement reflected.

Therefore, the link between intellectual property rights and innovation is essential to explore and understand. As things stand, very little empirical evidence exists on this relationship. Schankerman (1998) and Lerner (1994) study the effect of patenting on the valuation of firms, and Park and Ginarte (1997) and Gould and Gruben (1996) study the effect of stronger IPRs on economic growth. Neither of these studies, however, consider the influence of intellectual property protection on innovation *per se;*[1] nor do they allow for the possibility of the endogeneity of intellectual property rights. It is important to realise that the protection-innovation relationship may run both ways – not only may protection influence innovation, but the presence of innovations may well determine what level of protection is provided. Thus, it is often argued that developing countries provide weaker IPRs because they have few innovations to protect and want to benefit from foreign technology via imitation, whereas developed countries provide stronger protection because they have something to protect (Ginarte and Park, 1997; Lerner, 2002).

This paper attempts to correct for both the shortcomings noted above. We consider the relationship between research and development investment (in lieu of innovation) and an index pf patent rights (in lieu of intellectual property protection), in a two-equation framework. Our results show that the strength of IPRs has a strong positive influence on innovation. Section 2 sets up a theoretical model which motivates the estimation model. Section 3 discusses the estimating equations and data employed. Section 4 provides a discussion of the results and conclusions.

2. The theoretical model

Consider a monopolist[2] using CRS technology given by the relation

$$Q_t = A\, L_t^{\alpha}\, K_t^{1-\alpha} \qquad 0 < \alpha < 1 \qquad (1)$$

where Q is output, L is labour, K is the capital stock, and t the time period. We express the capital stock – comprising physical capital (K_P) and knowledge capital (K_K) – as

$$K_t = \theta K_{Pt} + (1-\theta) K_{Kt} \qquad 0 < \theta < 1 \qquad (2)$$

to allow the elasticities of output w.r.t physical and knowledge capital to differ. The physical capital stock adjusts between periods according to the relation

$$K_{Pt} = K_{P(t-1)} + I_t \quad (3)$$

where I is investment (and we ignore depreciation for simplicity). Similarly, the knowledge capital stock adjusts between periods according to the relation

$$K_{Kt} = BK_{K(t-1)}^{1-\sigma} R_{t-1}^{\sigma} \quad (4)$$

where B is the technological shock, and R_{t-1} is the research and development expenditure in period *t-1*. While (3) is an accounting relationship (4) is not, so that a doubling of the R&D expenditure does not necessarily augment the knowledge capital by like amount. The productivity of R&D expenditure will depend, inter alia, upon the skill levels of the personnel involved. Capturing skill levels by education levels (EDU), we have $\sigma = \sigma(EDU)$.

The adjustment in the physical capital stock naturally involves some cost, which would be directly proportional to the amount of investment undertaken, and the market rate of interest on borrowed funds (i). For our purposes, it suffices to specify this adjustment cost as

$$C_{1t} = iI_t \quad (5)$$

Similarly, the adjustment in the knowledge capital stock also entails some cost, which would be directly proportional to the amount of R&D expenditures undertaken, and the cost of funds (r) used for this purpose. The adjustment cost on this score may, then, be written as

$$C_{2t} = rR_t \quad (6)$$

Given the difficulty in raising market loans for R&D projects due to their risky nature, R&D investment often depends on internal funds (S). The cost of funds used for R&D would then depend upon i and S, i.e. $r = r(i, S)$.

Assuming that the firm operates for two periods (as in Lee and Shin, 2000), its period t profits may be written as

$$\pi_t \;=\; P_t(Q_t\,;IP_t)Q_t \;-\; wL_t \;-\; C_{1t} \;-\; C_{2t} \tag{7}$$

where P is the price of output, w is the nominal wage rate, IP is intellectual property protection, and the other variables are as defined above. The firm faces a downward-sloping demand curve such that P_t is a negative function of Q_t, given the 'institutional environment' within which it operates. Thus, the firm would be able to charge a relatively higher price for a given output if it had the benefit of strong intellectual property protection (IP) for its product, than if it did not.

Based on the realised current price and the distribution of the expected future price, the firm decides on the optimal employment and investments. Given the condition $\partial\pi_t/\partial L_t = 0$, optimal employment may be derived as

$$L_t \;=\; \left(\frac{1+\eta}{\eta}\right)^{1/(1-\alpha)} \left(\frac{w}{\alpha A}\right)^{1/(\alpha-1)} P_t^{1/(1-\alpha)}\; K_t \tag{8}$$

where η is the price-elasticity of demand. Substituting this expression in the profit function yields

$$\pi_t \;=\; g(\alpha)\;\; P_t^{1/(1-\alpha)}\,(\,K_{P(t-1)} + I_t + BR_{t-1}^{\sigma}\,) - iI_t \;-\; rR_t \tag{9}$$

where $g(\alpha) = [1 \,-\, \alpha\,\frac{1+\eta}{\eta}\;]\left(\frac{\alpha}{w}\right)^{\alpha/(1-\alpha)} A^{1/(1-\alpha)}\left(\frac{1+\eta}{\eta}\right)^{\alpha/(1-\alpha)}$.

Period 2 profit may then be written as

$$\pi_t \;=\; g(\alpha)\;\; P_2^{1/(1-\alpha)}\,(\,K_{P1} + I_2 + BR_1^{\sigma}\,) - iI_2 \tag{10}$$

(where we have omitted the last term in 'rR_2', because that would not figure in the firm's calculations given that period 2 is the last period). Using this expression, the condition $\partial\pi_2 \,/\, \partial I_2 = 0$, gives us

$$I_2 = \left[i\eta K_2 - g(\alpha)\, P_1^{1/(1-\alpha)} \eta K_2 - g(\alpha)\, P_1^{1/(1-\alpha)} (K_{P1} + BR_1^{\sigma}) \right] \left[g(\alpha)\, P_1^{1/(1-\alpha)} \right]^{-1} \qquad (11)$$

Substituting (11) in (10), we can re-write the latter as

$$\pi_t = i\eta K_2 - g(\alpha)\, P_1^{1/(1-\alpha)} \eta K_2 - i \left[i\eta K_2 - g(\alpha)\, P_1^{1/(1-\alpha)} \eta K_2 - g(\alpha)\, P_1^{1/(1-\alpha)} (K_{P1} + BR_1^{\sigma}) \right]$$

$$\times \left[g(\alpha)\, P_1^{1/(1-\alpha)} \right]^{-1} \qquad (12)$$

Using (9), period 1 profits may be written as

$$\pi_1 = g(\alpha)\; P_1^{1/(1-\alpha)} (K_{P0} + I_1 + BR_0^{\sigma}) - iI_1 - rR_1 \qquad (13)$$

In period *1* the firm chooses R_1 and I_1 to maximise $\Phi = \pi_1 + E(\pi_2)$. Being specifically interested in R_1, the condition $\partial\Phi / \partial R_1 = 0$ gives us[3]

$$R_1 = \left[\frac{rg(\alpha) E(P_2^{1/(1-\alpha)})}{\alpha B K_{K1}^{1-\sigma}} \right]^{1/(\sigma-1)} \Big\{ ig(\alpha)\, E(P_2^{1/(1-\alpha)})\; (2\eta + 1) - \left[g(\alpha)\; E(P_2^{1/(1-\alpha)}) \right]^2 (\eta + 1)$$

$$+ \; i(i - \eta) \Big\}^{1/(1-\sigma)} \qquad (14)$$

3. The estimating equations

The above model cannot be estimated, however, because firm-level data are not available for the strength of intellectual property protection.[4] Data for this variable are only available at the country-level. Keeping this in mind, based on the model above we specify the estimation equation as

$$BERD = f(IP,\ \Delta\, GDPPC,\ EDU,\ S_{t-1},\ RLR) \qquad (15)$$

where R&D investment is represented by business enterprise R&D as a proportion of GDP (*BERD*); the strength of intellectual property protection is measured by the Ginarte-Park index of patent rights (*IP*) which ranges from *0* to *5*, with higher numbers indicating stronger protection; expected market conditions or $E(P_2)$ are captured by the change in GDP per capita ($\Delta GDPPC$); the stock of human capital is measured by the average years of education for the population aged 15 and over (*EDU*); internal funds are proxied by gross domestic savings as a percentage of GDP, lagged one period(S_{t-1}); and the cost of borrowed funds is represented by the real lending rate of interest (*RLR*).

Using country-level data, however, introduces a problem. Although the strength of IPRs is exogenous to the R&D decisions of a firm (in a given country), it may not be exogenous for the totality of firms (in that country). Indeed, as we pointed out above, many argue that the strength of intellectual property rights provided by a country depends on its level of development (which, in turn, depends on the level of innovative activity in that country). In other words, variable *IP* is no longer exogenous. To circumvent this problem, we first derive instrumental variable estimates $\widehat{IP}$ using the following estimation equation, and then use $\widehat{IP}$ in lieu of *IP* in equation (15) above:

$$IP = h(GDPPC, EDU, GREVPC, EFI, BMP) \qquad (16)$$

where GDP per capita (*GDPPC*) and the stock of human capital (*EDU*) reflect a country's level of development;[5] government revenue per capita (*GREVPC*) measures the government's financial ability to provide protection; the economic freedom index (*EFI*) reflects the overall institutional climate (ranging form 0 to 10, with higher numbers indicating more freedom); and the black market exchange rate premium (*BMP*) proxies the openness of the economy to external competition.[6]

The dataset pertain to 44 developing and developed countries for the period 1981-2000. Because the relationships in question are of a long-run nature, we estimate them using quinquennial averages obtained from the annual data. Our procedure implies four 'observations' for each country ('1985' or the average for 1981-85, '1990' or the average for 1986-90, '1995 or the average for 1991-95, and '2000' or the average for 1996-00), or a total of 176 observations. All variables are in logs. Random effects

GLS estimates are derived for both equations.

4. Results and Conclusions

We first discuss the results for equation (16), which feeds into equation (15). Table 1 shows that all variables have the expected signs, the hypothesis that the regressand is randomly determined is strongly rejected, and the Hausman test strongly supports the random effects estimator. The strength of protection provided by countries does, indeed, appear to vary positively with their levels of development – the per capita GDP variable is significant at the 10% level using a one-tail test, and the human capital variable is highly significant at the 1% level. It might be too cynical, however, to ascribe the levels of protection solely to this consideration. The availability of resources to the government is also important, as evidenced by the strong significance of the per capita gross revenue variable. Finally, the strength of protection a country provides also depends positively on the competition it faces internationally, as is implied by the strong negative significance of the black market exchange rate premium variable. Only the economic freedom index is insignificant, but has the expected positive sign.

Coming to the estimation results of equation (15), Table 2 reveals that none of the variables have a wrong sign *and* are significant, the hypothesis that the dependent variable is randomly determined is strongly rejected, and the Hausman test strongly supports the random effects estimator. We find that the strength of protection has a strong positive influence on R&D expenditure. In addition, the demand-pull factor $\Delta GDPPC$ also has a strongly positive effect on the regressand. Both the human capital variable *EDU* and the internal funds proxy S_{t-1} have the expected positive effect on R&D expenditure, although they are insignificant using the conventional test criterion. The cost of funds variable *RLR* has the wrong sign, but is highly insignificant.

We further test the hypothesis that too strong a level of protection hurts innovation (Bessen and Maskin, 2004; Helpman, 1993), and the results are:

$$BERD = -3.493 + 0.734\, IP + 0.277\, IP^2 + 0.836\, \Delta GDPPC + 0.370\, EDU + 0.255\, S_{t-1} + 0.017\, RLR$$

(–5.40) (1.30) (2.50) (2.11) (0.97) (1.57) (0.31)

(with z-values in parentheses). We find, as above, that stronger protection implies stronger R&D (although at the 10% level using a one-tail test). This relationship does not become negative when levels of protection rise non-linearly – the coefficient of IP^2 is positive and strongly significant, although it is about one-third the coefficient of IP itself. The other variables behave as before, with the difference that now S_{t-1} is also significant (using a one-tail test).

Our results enable us to conclude that the strength of intellectual property protection that countries provide, has a strongly positive influence on business enterprise R&D expenditure and, thus, on innovation. This relation, it appears, does not turn negative as levels of protection rise non-linearly.

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Table 1

Random effects GLS estimates (dependent variable: IP)

Variable	Coefficient	z	90% confidence interval	
GDPPC	0.053	1.53	(–0.004	0.111)
EDU	0.291	2.76	(0.118	0.465)
GREVPC	0.061	2.54	(0.022	0.101)
BMP	–0.018	–3.96	(–0.025	–0.010)
EFI	0.009	0.08	(–0.163	0.181)
Intercept	–0.411	–1.89	(–0.769	–0.053)

No. of observations: 176

Wald χ^2 (all slopes 0): 119.47

R^2: 0.5052

Hausman (specification test): 0.243

Table 2
Random effects GLS estimates (dependent variable: BERD)

Variable	Coefficient	z	90% confidence interval	
IP	1.139	2.17	(0.274	2.004)
$\Delta GDPPC$	1.016	2.63	(0.381	1.652)
EDU	0.443	1.14	(–0.195	1.082)
S_{t-1}	0.207	1.27	(–0.061	0.475)
RLR	0.008	0.15	(–0.081	0.098)
Intercept	–3.270	–5.00	(–4.347	–2.194)

No. of observations: 176
Wald χ^2 (all slopes 0): 59.75
R^2: 0.4478
Hausman (specification test): 0.103

Notes

[1] Sakakibara and Branstetter (2001) is an exception, but it doesn't consider an explicit measure of protection as a regressor.

[2] Because IPRs bestows monopoly power. We could talk in terms of oligopoly instead, but that would complicate the analysis without adding to our understanding of the innovation-protection relationship.

[3] An expression for I_1 may be similarly derived. Evidence shows that while R&D Granger-causes physical investment, the reverse is not true (Lach and Schankerman, 1989).

[4] Moreover, such data would not show much variation across firms or over time for any given country.

[5] In many countries per capita GDP is high due to rent accruing from a special resource (e.g. petroleum), and does not reflect their level of technical development per se. To correct for this, we include the human capital variable.

[6] The data sources are: *IP* (Ginarte and Park, 1997), *EDU* (Barro and Lee, 2000), *EFI* (Gwartney and Lawson, 2004), *BMP* (Pick's Currency Yearbook, World Currency Yearbook), and other variables (UNESCO and World Bank).