CDE
October, 2002

Does Intellectual Property Lead to Intellectual Property Protection?

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Working Paper No. 108

Centre for Development Economics
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Abstract

Researchers studying the differential commitment of countries to intellectual property rights, often appear to run into the claim that countries with a relatively higher and significantly changing technological base (the developed countries) *opt* for relatively stronger protection, whereas those with a relatively low and essentially unchanging technological base (the developing countries) *opt* for weaker protection. While the reasons for such strategic choice may vary between the two sets of countries, it appears to be a short step from the above assertion to the claim that such behaviour on the part of the developing countries results in huge trade losses for the developed countries. Using cross-country panel data for the period 1981-1995, this paper finds that the generation of intellectual property or technological change (proxied by private R&D investment) does not have any significant positive influence on the strength of intellectual property protection that nations provide.

JEL Classification: O 34, O 31

Keywords: Intellectual Property, Protection, Technolgical Change

Does Intellectual Property lead to Intellectual Property Protection?

The agreement on Trade Related Intellectual Property issues (TRIPs) reached in April 1994 under the aegis of the GATT/WTO, committed the member signatories to harmonizing their intellectual property laws within a specified time frame. It also served to highlight the widely diverging strengths of protection that different nations provide to intellectual property. In the case of patent laws, for instance, nations have differed with respect to coverage (in terms of, for instance, the broad categories of inventions patentable), duration (or the number of years of protection granted), conditions for the revocation of patents once granted (on account of 'non-working' or else compulsory licensing under certain situations), when a patent application may be challenged (pre-grant or post-grant opposition), enforcement procedures (whether or not preliminary injunctions are allowed in case of an alleged infringement, who carries the burden of proof), and so on. Similarly, numerous differences have obtained across nations with respect to the other instruments of intellectual property protection (copyrights, trademarks, trade secret laws etc.) as well (Gadbaw and Richards 1988).

Researchers studying different countries' commitment to intellectual property protection often appear to run into the claim, that countries with a relatively higher technological base and exhibiting 'significant' technological change (the developed countries) have an incentive to provide relatively stronger protection to intellectual property, whereas countries with a relatively low and essentially unchanging technological base (the developing countries) have little incentive to do so. Thus, countries such as the United States, Germany, Japan etc. provide relatively stronger intellectual property protection, whereas many others such as India, Brazil, Argentina etc. do not. While this possibility has been acknowledged in the literature (McLeland and O'Toole 1987; Frame 1987; Ginarte and Park 1997), few researchers have studied it formally[1]. McLeland and O'Toole compare the relative commitments of developed and developing countries in the area of pharmaceuticals, but their 'analysis' is limited to the assertions that the "... LDC perspective is different primarily because there are few research-based pharmaceutical companies located in those countries", and that "[M]ost indigenous 'manufacturers are compounders who purchase the active ingredient ... and mix and package the drug ...". They do not offer any evidence on these sweeping statements - how true this might be for, say, India, Brazil, Argentina, Cuba etc; or whether their claims pertain to other industries as well[2]. Frame (1987) in a fairly superficial paper, considers a group of 8 countries with a 'low' commitment to protect intellectual property, and claims that U.S. trade losses on account of inadequate protection and trade in counterfeit goods runs into several billions of dollars. He does not, however, show that the latter phenomenon is linked to the former set of countries, nor whether the levels of protection obtaining in his set of countries is higher or lower than those in other developing countries, nor what he means by 'low' levels of commitment to protect intellectual property. Ginarte and Park (1997), on the other hand, attempt to study formally the relationship between the commitment to protect intellectual property and various determinants. They find weak evidence in support of the above-mentioned claim that the less-developed countries are the ones with a relatively weaker commitment to provide protection. Their estimation, however, is likely to be subject to considerable simultaneity bias, as they regress an index of protection on R&D expenditure; for the latter is likely to be a function of the former, and taking lagged values of the regressors (as they do) is not enough to take care of this endogeneity bias. Thus, the empirical evidence is thin and hardly supportive of any generalisation.

This paper, therefore, attempts to examine empirically whether the generation of intellectual property, or technological change, leads to the strengthening of laws pertaining to its protection. This relationship is captured at the economy-wide level, employing cross-country data on the strength of intellectual property protection, technological change and other country-specific control variables. The estimation results show unambiguously, that the generation of intellectual property or technological change (represented by research and development expenditure) does not have any significant positive effect on the strength of intellectual property protection provided by nations (as represented by an index of patent rights). It is our conjecture, that intellectual property laws, as also other laws, are not variables automatically determined by market forces, but are instead determined by a more complex and circuitous political economy process. Consequently, they are slow to change and need not be responsive to changes in the level of technological development of nations in any systematic manner.

Section 2 considers the arguments underlying the relationship sought to be estimated in this paper in somewhat greater detail, and spells out the estimation model. Section 3 briefly discusses the data samples and the estimation procedure adopted. Section 4 presents the estimation results, and section 5 outlines some broad conclusions.

2. Intellectual Property and Its Protection: The Estimation Model

When considering a country's commitment to the protection of intellectual property, an interesting question that has been raised in the literature is, which countries provide strong protection and which ones weak protection? Thus, Gould and Gruben (1996) note that "... developing countries have traditionally offered shorter periods of protection for patents than have developed countries". Is the strength of intellectual property protection that a country provides determined by the level of its technological base and inventive effort, controlling for other relevant factors? Stated alternatively, ceteris paribus, do countries that exhibit a relatively low technology base and a low level of inventive effort (primarily developing countries) *opt* for weak intellectual property protection, and those that exhibit a relatively higher technology base and a higher level of inventive effort (primarily developed countries) *opt* for a régime of strong(er) intellectual property rights?

Low levels of inventive activity, as in many developing countries, imply the availability of a relatively narrow technology base, and hence a range of goods and services that is narrower, of poorer quality and possibly higher priced[3]. One way to circumvent these disadvantages is to allow 'cheap' technology imports through imitation, within a system of relatively weak intellectual property protection. Thus, for instance, some developing countries historically did not offer product patents on pharmaceuticals; instead, they offered process patents, which implied that firms in these countries could (and did) synthesize various drugs by alternative processes *even when product patents on these drugs were valid in other (developed) countries*.

Once countries begin to invest 'sizable' proportions of their total product in inventive activity, as in newly-industrialized countries in the recent past and the older industrialized countries earlier, they appear to switch to stronger protection of intellectual property, because now there is something to protect. If they don't protect this property themselves, they cannot reasonably expect other countries to protect it either. Can India, for instance, expect other nations to respect its claim over Basmati rice when it doesn't provide for protection of 'geographical indications' itself[4]? Various intellectual property instruments, therefore, are employed strategically to keep competitors from gnawing away the profit margins through imitation. In other words, the generation of intellectual property brings in its wake measures to protect it. For these reasons, it appears - strategic reasons on the part of the technology-importing countries or the South, and vested interests on the part of the technology-exporting countries or the North - we may expect a positive relationship running from the level of inventive effort or technological change in a country, to the strength of intellectual property protection that it provides.

Thus, various arguments may be proffered - some to explain the behaviour of net technology-importers and some to explain the behaviour of net technology-exporters - to establish, à priori, a relationship between the level of inventive activity and the strength of intellectual property protection across nations. But how valid these arguments are in practice, is not very clear from the available evidence. This paper attempts to bridge this gap between conjecture and the ground reality, by providing further empirical evidence on the above-mentioned relationship. Before proceeding to the estimation we need to delineate the model. For this purpose, we need to define the regressand and the regressors.

The regressand

While ideally one ought to consider a range of intellectual property instruments (patents, trademarks, copyrights, trade secrets) in constructing an index of the strength of intellectual property protection, in practice this may not be feasible on account of data constraints, particularly in the case of developing countries. This need not be a serious limitation, however, in view of the fact that the inter-country variation in some instruments such as trademarks and (to a lesser extent) copyrights has traditionally been rather small (Gadbaw and Richards 1988)[5]. Not considering the latter two instruments in constructing an overall index of protection, therefore, should not prove a serious omission.

There appears to be a consensus in the literature, that the most dramatic differences in the protection afforded to intellectual property across nations, obtain in the sphere of patents. Patent protection differs across countries in several important respects. While in some countries a wide category of inventions are granted both product and process patents (e.g. in Germany, Japan, UK, US), in some only process patents were granted in certain areas such as pharmaceuticals and chemicals (e.g. India, Mexico, Venezuela), and in some not even process patents may be allowed in certain areas such as food products (e.g. India, Thailand, Venezuela). *Second*, the number of years of patent protection varies greatly between nations. In some countries patent protection lasts only five to ten years (e.g. Jordan, Sri Lanka); in others, it lasts between 15 to 20 years (e.g. France, Germany, UK, US). What complicates the duration aspect further is the fact, that some countries measure patent duration from the date of application for the patent (e.g. Japan, Jordan, Nigeria), others measure it from the patent publication date[6] (e.g. Australia, Austria, India, Korea), and still others measure it from the date the patent is granted (e.g. Canada, Mexico, Pakistan, Portugal, Iceland). *Third*, the patent laws in different countries may differ with respect to the conditions under which patents may be 'suspended' once granted. Thus, in some countries patents may be suspended on account of 'non-working' or 'insufficient working' (e.g. India), or else compulsory licensing (e.g. Australia, India, Ireland, Nigeria, UK), or else national needs such as defence (e.g.Austria, France, Italy, Mexico) or public health (e.g. Canada, France, India, Ireland, Nigeria). *Fourth*, countries may differ with respect to the ease with which patent claims may be challenged. While some countries allow pre-grant opposition (e.g. Japan), others only allow post-grant opposition (e.g. France, Germany, UK). *Fifth*, countries may differ with regard to the strength of enforcement procedures available to patentees and patent administrators. Thus, some countries may allow preliminary injunctions in case of an alleged infringement (e.g. US), whereas others may not (e.g. India); again, in some countries the burden of proof of an alleged infringement may be on the complainant, while in others it may be on the appellant. Many other aspects may be added to this list in describing the inter-country differences in patent laws. Ginarte and Park (1997) construct an index of patent rights focusing on the five important aspects of coverage, duration, membership in international patent agreements, conditions for loss of protection and enforcement mechanisms available. The index ranges from zero to five, with higher values of the index indicating stronger protection. We use this index of patent rights (IP) as the regressand in this study[7].

The regressors

The hypothesis in question is whether countries with higher levels of inventive activity or technological change, offer higher levels of protection to the fruits of such activity. We propose to represent inventive activity by *private research and development expenditure as a proportion of gross national product* (PRDI), which is obtained using cross-country data on R&D expenditure as a proportion of GNP (RDI)[8] and the government's share of gross domestic R&D expenditure (GOVSHRD). The reason we focus on private inventive activity is, that it is the private sector which appears to demand the protection levels (high or low) that it considers suitable. Although all R&D expenditure does not necessarily translate into intellectual property, this variable is more closely related to inventive activity than are, say, others based on patent data[9].

The level of intellectual property protection that a country provides will also depend on its capacity to do so, both its financial capacity as well as its human capital capacity. Thus, countries with a larger surplus of financial resources are better able to provide stronger protection, simply because they can afford to. There are probably large fixed costs of providing such protection - for this would include infrastructure for patent offices, patent examiners, databases, enforcement officers, courts etc. - which countries with larger surpluses would be in a better position to provide. We represent this financial capacity by *gross domestic savings as a proportion of GDP, lagged one period* (S_{t-1}).

In addition to financial resources, the requirement of competent patent examiners (technically skilled for the purpose), patent lawyers, enforcement personnel (suitably informed), judges etc., would require suitable human capital resources. We capture this human capital resource requirement in terms of the *average number of years of formal schooling of the population aged 15 or more* (EDU).

The market size would partly determine how much profit potential any intellectual property has and may, therefore, influence the strength of intellectual property protection that a government chooses to provide over time. Thus, larger markets, insofar as they indicate a greater profit potential ceteris paribus, may attract greater intellectual property protection. We represent this factor by the *current GDP per capita* (GDPPC).

Finally, political stability appears to be important for the development of institutions in a country. It stands to reason, that countries faced with political instability may lack the conditions (the political consensus and/or the decision-making apparatus and/or the infrastructure), relatively speaking, to introduce and implement what they consider to be the appropriate institutions - intellectual property laws in the current context. We represent this factor by a fairly comprehensive 'state failure' dummy, using data on genocides, politicides, ethnic wars, revolutionary wars and abrupt régime changes towards autocratic rule (for the data see Esty et.al. 1998). The *instability dummy* (ID) is defined to equal 1 for a country exhibiting one or more of the above-mentioned phenomena in any year, and 0 otherwise.

Estimating R&D expenditure

A problem with the set of regressors discussed above, is the likely endogeneity bias involved in using variable PRDI or *private R&D expenditure share in the national product*; for it may be argued that inventive activity is itself a function of the strength of protection provided to it. To take care of this problem we propose to first estimate PRDI as a function of various exogenous variables, and then use the *estimated RDI* values (PRDIHAT) in lieu of PRDI. The exogenous variables used in instrumenting PRDIHAT are briefly discussed below.

R&D expenditure is found to be pro-cyclical for several reasons. One important reason is the increased availability of internal funds (Hall 1992; Himmelberg and Petersen 1994), while a second reason is demand-pull forces indicating increased profitability (Geroski and Walters 1995). We represent the former by *gross domestic savings as a proportion of GDP, lagged one period* (S_{t-1}), and the latter by the *ratio of current GDP per capita to the previous period's GDP per capita* (ΔGDPPC)[10]. Note, that we did not want to introduce current GDP as a regressor to capture the pro-cyclicality of PRDI, because that would leave the causation mechanism opaque.

Human capital is central to research and development (Romer 1990). Furthermore, more educated countries are better able to absorb and innovate on the inventions made elsewhere (Nelson and Phelps 1966). Researchers often use literacy rates to capture this factor, although literacy statistics (based on whether the respondent can sign his name, or whether he can identify a certain number of characters of a given language etc.) are not particularly indicative of individuals' skill levels. Data on technical personnel - scientists, engineers, technicians etc. - might be more relevant, but are harder to come by, especially for developing countries. Again, primary school enrolment rates would not be adequate for the task, because too many countries have already achieved full enrolment at this level; quite apart from the fact that we should use a stock and not a flow measure of human capital. We capture the stock of human capital using data on the *average number of years of schooling in the population aged 15 or more* (EDU).

Political stability is of significance in nurturing the economic climate. Expensive and long-gestation investments as in R&D easily get put off if there is political instability. This may be especially true if part of the investment is to be made by non-resident entities. In other words, political instability is known to contribute greatly to economic instability. We represent this factor by the comprehensive 'state failure' dummy (ID) mentioned above.

Even though internal funds are found to be the most important source of financing private R&D activities, simply because financial institutions will not lend for such risky ventures (Hall 1992; Himmelberg and Petersen 1994), we might want to include the *real lending rate of interest* (RLR) to reflect the opportunity cost of internal funds (Guellec and Ioannidis 1997).

Lastly, the trade orientation of a country might be of significance in determining the pace of its inventive activity; for relatively open economies face more competition and may, therefore, be forced to invest more in research and development (Edwards 1992; World Bank 1987; Krueger 1978; Bhagwati 1978). While several different measures such as exports shares, trade shares, effective tariff rates, real exchange rate distortions etc. have been used to represent trade orientation, one that seems to be preferred is the black market exchange rate premium (Gould and Gruben 1996). We represent trade orientation, therefore, by a *black market premium dummy* (BMPD), which equals 1 for the relatively closed economies (or those for which the black market premium[11] exceeds the sample median), and 0 for the others.

From the above discussion it should be clear that we first estimate the equation

$PRDI_t = f(S_{t-1}, \Delta GDPPC_t, EDU_t, ID_t, RLR_t, BMPD_t)$ (1)

to derive estimated values of PRDI, i.e. $PRDIHAT_t$. Using this instrumental variable, in the second step we then estimate the equation

$IP_t = g(PRDIHAT_t, S_{t-1}, EDU_t, ID_t, GDPPC_t)$ (2)

where all the variables used in these two equations have been defined in the discussion above. It is this second equation that is of primary interest to us.

3. Data Set and Methodology

The variables used for estimation were computed using data from diverse sources (given in Appendix 3). The sample comprised 31 developed and developing countries (Table 1); which was determined almost wholly by the availability of data on private R&D expenditure. The relationship between the strength of protection and technological change is likely to be of a long-run nature, because protection laws are slow to change. So we average the yearly data to get quinquennial averages[12], which are then used for estimation. Descriptive statistics for the variables are presented in Appendix 1.

Data on all variables discussed above were available for 29 countries for the period 1981-1990. Averaging these data quinquennially implies two time points for each country, '1985' or the average for 1981-1985, and '1990' or the average for 1986-1990, and hence a total of 58 observations. Estimations employing this sample are called 'Exercise 1'. If we agree to drop variable RLR from the estimation of the instrumental variable PRDIHAT (on the argument that the received I-O literature shows internal funds, rather than borrowed funds, to be important in determining R&D), our sample size rises to 30 countries, now including Pakistan for which data on RLR were not available. Estimations based on this sample are designated 'Exercise 2'. If we agree to use the literacy variable LIT in lieu of variable EDU, our sample further increases to 31 countries, now including Nigeria for which data on EDU were not available. Regressions based on this sample are labelled 'Exercise 3'. Finally, 'Exercise 4' regressions are limited to the 18 OECD countries in our data set[13]. For this set of countries, data were available for the longer period 1981-1995; however, we had to use variable LIT in lieu of the human capital variable EDU, because data on the latter were available only till 1990. Also, we were forced to use World Bank data (World Bank 2000) for the demand-pull variable ΔGDPPC in place of the Penn World Table (2001), because the latter only reports data till the early-1990s.

In a large number of applications using cross-country panel data, treating the individual country effects as 'fixed' appears to be the automatic choice. Nerlove (1967, 1971), Maddala (1971) and Nickell (1981), however, show that OLS estimates treating individual effects as fixed may give rather poor parameter estimates. The advantage of the random effects specification follows from the substantially higher degrees of freedom that it affords and, very importantly, from the fact that it makes use of the 'between country' variation in the sample (whereas a 'fixed effects specification does not). This latter consideration is likely to be of significance with regard to our data set for two reasons. First, the number of cross section units exceeds the number of time points available by a factor of about 15 - whereas Taylor (1980) shows that even in situations where this factor is much lower, the random effects estimator is more efficient. Second, as pointed out above, changes in the strength of intellectual property protection in a given country tend to be few and relatively small over the sample period (and even over longer spans of time), whereas differences in protection levels *across* countries (say, the developed and developing countries) are relatively much larger. For all these reasons we prefer to use a random effects specification in our estimation exercises, i.e.

$y_{it} = \overline{\beta}_1 + \beta_k x_{kit} + \mu_i + \varepsilon_{it}$ $\qquad$ $i = 1, \ldots, N; t = 1, \ldots, T$

where $\mu_i \sim N(0, \sigma_\mu^2)$

$\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$

$E\mu_i\varepsilon_{ijt} = 0, \forall$ i, j and t,

$E\mu_i\mu_j = 0, \quad i \neq j,$

$E\varepsilon_{it}\varepsilon_{js} = 0, \quad i \neq j, t \neq s. \quad (2)$

where the regressand y_{it} refers to the index of protection variable IP for the i^{th} country in the t^{th} year, while x_{kit} refers to the k^{th} regressor for the i^{th} country in the t^{th} year[14]. The variables are in (natural) logs, and are stationary; and estimation yields feasible GLS estimates which are discussed below.

4. Estimation Results

To begin with we categorize our sample of countries into five groups based on their private R&D expenditure shares in gross national product (Table 1). For each group of countries we also note the index of intellectual property protection and the average of these indices. There appears to be an à priori positive relationship between the R&D expenditure shares and the average indices of protection. Note, however, that as we move from group 2 ($0.5 \leq$ PRDI < 1) through group 5 ($2 \leq$ PRDI < 2.5), although the R&D expenditure shares increase substantially, the average index of protection increases only marginally from about 3.6 to about 3.9. Further, the increase is not monotonic - while the average R&D expenditure share of group 4 exceeds that of group 3, the index of protection for group 4 is lower than that for group 3. In any case, to establish such a relationship with any degree of confidence would require us to introduce appropriate control variables that may determine the strength of intellectual property protection that nations provide. This is what we proceed to do next.

The estimation results of 'Exercise 1'

The random effects GLS estimates for 'Exercise 1' are presented in Table 2. We follow a general-to-specific modelling approach (Charemza and Deadman 1997), and prefer to use the 'root mean squared error' (R.M.S.E) and 'Schwarz criterion' (SC) to guide us in model selection[15]. Column (1) of Table 2 (i.e. model (1)) shows that the education variable has a strong positive effect on the strength of protection provided, which appears to support our conjecture that countries with relatively larger stocks of skilled manpower (in the form of competent patent examiners, technicians maintaining the data bases, patent lawyers, judges etc.) are the ones who are able to provide relatively higher levels of intellectual property protection. The instrumental variable PRDIHAT[16] has a *negative* and significant influence on the regressand, implying that countries with higher levels of private R&D expenditure shares provide relatively *weaker* protection to intellectual property! But this is just the opposite of the hypothesis that we set out to investigate, and does not appear to make sense. Therefore, we must discount this result, and see whether it is supported or contradicted by those of the subsequent estimation exercises.

The financial resources variable S_{t-1}, however, has the wrong sign even though it is insignificant. Model (2), therefore, drops this variable. This does not affect the results in any way, and variables GDPPC and ID continue to be insignificant. Model (3) drops the instability dummy variable and model (4) omits both ID and GDPPC. The results are essentially unchanged. This model has the least root mean squared error and the smallest Schwarz statistic. The (F-distribution variant of the) Hausman statistic or m(F) equals 1.744, and has a p-value of 0.175, supporting the estimation of a random effects specification.

The estimation results of 'Exercise 2'

Table 3 reports the GLS estimation results of 'Exercise 2'. Model (1) results (i.e. column (1) of the Table) reveals that all variables, excepting the financial resources variable S_{t-1}, have the expected signs, although none are statistically significant. Model (2) omits variable S_{t-1}, and model (3) omits both S_{t-1} and the instability dummy ID, but neither omissions change the results. Finally, model (4) also drops EDU. We now find that variable GDPPC is positive and marginally significant; appearing to support the conjecture that a larger profit potential, indicated by a larger market, may induce nations to provide stronger protection. The instrumental variable PRDIHAT[17], however, continues to be statistically insignificant, although it has the expected positive sign. Model (4) has the minimum root mean squared error and also minimizes the Schwarz criterion. The (F-distribution variant of the) Hausman statistic m(F) equals 7.415 with a p-value of 0.001, and does not appear to support the random effects specification; however, a fixed effects model gives us virtually the same results (although for various reasons mentioned above we should eschew a fixed effects specification in this context).

The estimation results of 'Exercise 3'

From the 'Exercise 3' regression results presented in Table 4, we find that GDPPC has a positive and marginally significant effect on the strength of intellectual property protection that a country provides. Again, the literacy variable has a positive effect on the regressand, which is marginally significant using a one-tail test. The instrumental variable PRDIHAT[18], the foremost variable of interest to us, is insignificant although it has the right sign. Of the other variables, only S_{t-1} has a wrong sign. So model (2) drops this variable, but this does not change the earlier results in any substantive manner. The only difference is, that the coefficient of PRDIHAT is now negative, although that does not matter because the variable continues to be insignificant. Model (3) also omits the instability dummy variable ID, in addition to S_{t-1}. This does not change the earlier results either. The coefficient of the literacy variable is positive and marginally significant using a one-tail test. The market-size/profit-potential variable GDPPC also has a positive and marginally significant influence on the regressand. The technological change variable PRDIHAT is still, however, statistically insignificant. Model (3) has the least root mean squared error and minimizes the Schwarz criterion. The (F-distribution variant of the) Hausman statistic m(F) equals 5.484 with a p-value of 0.002, and does not appear to support the random effects specification. A fixed effects model, however, gives us the

same results as regards the variable PRDIHAT (although for all the reasons mentioned above we should eschew a fixed effects specification in this instance).

The estimation results of 'Exercise 4'

'Exercise 4' restricts the data set to the OECD countries in our sample. Although we now have a smaller set of countries (only 18), we have data for a longer time period 1981-1995. As noted above, however, this sample constrains us to use literacy rates (LIT) as the human capital variable, because data on EDU were not available till 1995. Further, we drop the political instability variable ID from our set of regressors, because this variable equals 0 for all the OECD countries; so that including it would lead us into a 'dummy variable trap'. The random effects GLS estimation results are reported in Table 5. From the model (1) results in column (1) we find, that the technological change variable PRDIHAT[19] exerts a positive and marginally significant influence on the dependent variable. The market size variable GDPPC is also positive and significant. The financial resources variable S_{t-1}, however, has the wrong sign. Model (2), therefore, omits this variable. We now find that the literacy variable LIT has a positive effect on the dependent variable which, albeit, is only significant using a one-tail test. Further, the market size variable GDPPC is no longer significant. More importantly, the instrumental variable PRDIHAT does not retain even its marginal significance. Model (3) further drops variable GDPPC. We now find that the significance level of the literacy variable improves somewhat, but variable PRDIHAT continues to remain insignificant. The root mean squared error is minimized, but not the Schwarz criterion which, albeit, is smaller than that of model (2). The (F-distribution variant of the) Hausman statistic m(F) equals 1.088 and has a p-value of 0.345, supporting the estimation of a random effects specification.

5. Conclusions

In this paper our intent was to investigate the claim, often implicit, that countries with a relatively higher technological base and exhibiting greater technological change tend to provide relatively stronger protection to intellectual property, whereas countries with a weaker and essentially unchanging technological base have no incentive to do so. Indeed, the latter set of countries may well have an incentive to provide relatively weaker protection insofar as that facilitates imitation. We found no evidence to support the above-mentioned claim, to the extent that the instrumental variable for technological change was *not* found to have a significantly positive influence on the strength of intellectual property protection provided by nations, even when several pertinent control variables were allowed for.

Even though we tested the above-mentioned claim made in the literature we, personally, would not expect it to be upheld. An important reason for this is, that intellectual property laws are LAWS, and not merely some economic variable whose magnitude is automatically determined by the behaviour of the market. Most important laws - and certainly those relating to intellectual property - are often the result of long drawn out debate not just by the experts in the area to which the laws in question may pertain, but also the executive, the judiciary and sundry other members of the polity. Changes in laws, therefore, tend to be slow and sometimes incremental, and are often vexed. For this reason, one should not expect intellectual property laws to change 'endogenously' with any regularity with respect to changes in the technological base of the economy.

Our results imply that empirical evidence does not support the assertion, that developing countries opt for weak protection to allow imitation. (As a corollary, researchers need not worry about endogeneity bias when estimating the incentive effects of intellectual property protection on technological change.) One would, therefore, need to look for other explanations for differences in the strength of protection provided by developing and developed countries. Our analysis points towards differences in the human capital resource base and potential market size as distinct possibilities. If countries indeed choose the level of protection that suits their level of development best, coercing them to adopt the same laws under the aegis of the TRIPs agreement should result in differential enforcement behaviour, with nations which have low levels of R&D opting for weak enforcement and those having high levels of R&D opting for strong enforcement. To the extent that developing countries in any case exhibit weaker enforcement of protection laws, the forced homogenisation of these laws under the TRIPs agreement implies that differences in the effectiveness of enforcement should now widen, or may assume more subtle forms than hitherto. Tracking such changes in the years to come should, then, constitute an additional test of the hypothesis investigated in this paper.

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Table 1

Private R&D expenditure and Intellectual Property Protection, 1981-1990

0 ≤ PRDI* < 0.5		0.5 ≤ PRDI < 1		1 ≤ PRDI < 1.5		1.5 ≤ PRDI < 2		2 ≤PRDI< 2.5	
Country	**IP***	**Country**	**IP**	**Country**	**IP**	**Country**	**IP**	**Country**	**IP**
Indonesia	0.330	Canada	2.760	Finland	2.950	Sweden	3.685	Japan	3.940
Venezuela	1.350	Norway	3.290	U.K.	3.570				
Mexico	1.515	S. Africa	3.570	S. Korea	3.775				
India	1.550	Denmark	3.830	France	3.900				
Thailand	1.850	Austria	4.025	Belgium	3.975				
Portugal	1.980	Italy	4.050	Netherlands	4.240				
Pakistan	1.990			U.S.A.	4.520				
Iceland	2.120								
Singapore	2.570								
Jamaica	2.860								
Mauritius	2.890								
Ireland	2.990								
Nigeria	3.050								
Sri Lanka	3.120								
Australia	3.275								
Spain	3.455								
Av. IP	2.306		3.588		3.847		3.685		3.940

Note: * PRDI - Share of private R&D investment in GNP; IP - Index of protection.

Table 2

'Exercise 1' - Random Effects GLS Estimates; Dependent Variable: IP

Variable	**(1)**	**(2)**	**(3)**	**(4)**
S_{t-1}	-0.040			
	(-0.512)			
EDU	0.354	0.347	0.341	0.361
	(2.666)	(2.688)	(2.698)	(3.555)
GDPPC	0.019	0.010	0.017	
	(0.296)	(0.167)	(0.297)	
ID	-0.077	-0.685		
	(-0.630)	(-0.575)		
PRDIHAT	-0.002	-0.002	-0.002	-0.002
	(-3.827)	(-3.824)	(-3.813)	(-3.879)
Intercept	0.416	0.386	0.332	0.447
	(0.861)	(0.828)	(0.757)	(2.051)
R.M.S.E	0.2760	0.2519	0.2117	0.0578
SC	0.0017	0.0015	0.0014	0.0013
F(H_0: all slopes 0)	43.2760	50.7420	61.5550	82.3930
$\bar{R}^2$	0.3565	0.3591	0.3603	0.3690
Observations	58	58	58	58

Note: T-statistics are in parentheses

Table 3

'Exercise 2' - Random Effects GLS Estimates; Dependent Variable: IP

Variable	**(1)**	**(2)**	**(3)**	**(4)**
$\mathbf{S_{t-1}}$	-0.156			
	(-1.089)			
EDU	0.110	0.079	0.077	
	(1.238)	(1.008)	(1.004)	
GDPPC	0.077	0.075	0.087	0.114
	(1.002)	(1.037)	(1.294)	(1.818)
ID	-0.127	-0.090		
	(-0.862)	(-0.653)		
PRDIHAT	0.377	0.246	0.219	0.247
	(1.520)	(1.095)	(1.001)	(1.128)
Intercept	0.473	0.015	-0.082	-0.193
	(0.635)	(0.029)	(-0.167)	(-0.397)
R.M.S.E	0.6714	0.3671	0.3032	0.2889
SC	0.0026	0.0021	0.0019	0.0018
F($\mathbf{H_0}$: all slopes 0)	33.1100	34.5330	42.3280	56.8280
$\bar{R}^2$	0.1369	0.1080	0.1129	0.1149
Observations	60	60	60	60

Note: T-statistics are in parentheses

Table 4

'Exercise 3' - Random Effects GLS Estimates; Dependent Variable: IP

Variable	**(1)**	**(2)**	**(3)**
S_{t-1}	-0.052		
	(-0.459)		
LIT	0.080	0.078	0.083
	(1.398)	(1.399)	(1.504)
GDPPC	0.138	0.135	0.127
	(1.860)	(1.966)	(1.896)
ID	-0.030	-0.056	
	(-0.285)	(-0.805)	
PRDIHAT	0.088	-0.099	-0.097
	(0.248)	(-0.301)	(-0.301)
Intercept	-0.218	-0.249	-0.193
	(-0.396)	(-0.529)	(-0.420)
R.M.S.E	0.4628	0.3419	0.3240
SC	0.0026	0.0020	0.0018
$F(H_0$: all slopes 0)	33.4230	36.0130	44.0450
$\bar{R}^2$	0.0972	0.0914	0.0945
Observations	62	62	62

Note: T-statistics are in parentheses

Table 5

'Exercise 4' – Random Effects GLS Estimates; Dependent Variable: IP

Variable	**(1)**	**(2)**	**(3)**
S_{t-1}	-0.393		
	(-3.155)		
LIT	0.433	2.352	2.538
	(0.241)	(1.321)	(1.533)
GDPPC	0.218	0.119	
	(2.096)	(1.094)	
PRDIHAT	0.172	0.076	0.113
	(1.747)	(0.765)	(1.166)
Intercept	-3.102	-11.516	-10.343
	(-0.390)	(-1.465)	(-1.352)
R.M.S.E	66.5050	64.9655	61.2764
SC	0.0071	0.00811	0.00806
F(H_0: all slopes 0)	193.6030	216.2680	316.3610
$\bar{R}^2$	0.3620	0.2473	0.2473
Observations	54	54	54

Note: T-statistics are in parentheses

Appendix 1

Means and standard deviations of the variables, 1981-90

Variable	Mean	Standard deviation
RDI	1.205	0.807
PRDI	0.589	0.581
S_{t-1}	20.701	8.762
ΔGDPPC	1.112	0.126
EDU	6.989	2.278
LIT	87.973	17.757
IP	2.940	0.977
GDPPC	8417.400	4917.300
BMPD	0.500	0.504
ID	0.159	0.367
RLR	3.953	7.966

Appendix 2

Definitions of variables

PRDI: Private (or non-public) R&D expenditure as a proportion of GNP (%)

RDI: R&D expenditure as a percentage share of GNP (%) (used to compute PRDI)

GOVSHRD: Government share of gross domestic R&D expenditure (%) (used to compute PRDI)

S_{t-1}: Real savings share of GDP (at 1985 international prices), lagged one period (%)

ΔGDPPC: Real GDP per capita (chain index in 1985 international prices) as a proportion of the previous period real GDP per capita (US $$)

EDU: Average number of schooling years in population over 15 (years)

LIT: Total literacy rate in population over 15 (%)

IP: Index of patent protection

BMPD: Black market exchange rate premium dummy

ID: Political instability dummy

RLR: Real lending rate of interest (%)

Appendix 3

Data sources

RDI: World Bank (2000)

GOVSHRD: United Nations (1999)

S_{t-1}: Heston et.al. (2001)

ΔGDPPC: Heston et.al. (2001), and World Bank (2000) (for 'Exercise 4' regressions).

EDU: Barro and Lee (2000)

LIT: World Bank (2000)

IP: Ginarte and Park (1997)

BMPD: Pick's Currency Yearbook and World Currency Yearbook (various years)

ID: Esty et.al. (1998)

RLR: World Bank (2000)

Notes

1. Although there are numerous studies, theoretical as well as empirical, that focus on the *reverse* causality running from the strength of intellectual property protection to the intensity of the innovative effort (see Evenson 1990 and the references therein, Gould and Gruben 1996, Park and Ginarte 1997, Schankerman 1998, Lanjouw and Cockburn 2001, Sakakibara and Branstetter 2001).

2. It is of some interest that the authors thank the Pharmaceutical Manufacturers Association (presumably in their home country) for support for their paper.

3. Especially in the absence of adequate import opportunities given foreign exchange constraints (as is true of most *non*-oil-exporters).

4. 'Geographical Indications' are a new form of protection mooted under the TRIPs agreement, whereby the name of a particular product 'indicates' that the product emanates from a particular region (of the world). Famous examples include Basmati rice (from India and Pakistan), Champagne (from the French province of the same name), Scotch (from Scotland), and many others. These names, by implication, may not be used by producers of other similar but essentially different products, in order to protect the association of the (supposed or real) characteristics of the products in question with their names.

5. Of course, the implementation and enforcement of trademarks and copyrights may show substantial variation across countries, but data on these aspects is the most difficult to come by and incorporate in any index of protection.

6. Patent applications are published by patent offices in official gazettes.

7. Rapp and Rozek (1990) provide an alternative index. Their index is based on a comparison of the patent laws of individual countries with the guidelines proposed by the US Chamber of Commerce's Intellectual Property Task Force (presented in *Guidelines for Standards for the Protection and Enforcement of Patents*). The Ginarte-Park index is superior in many respects, as it looks into various facets of patent protection in greater detail, and therefore makes for greater variation in the index of protection even between the developed countries.

8. R&D data were available as proportions of GNP and not GDP, but the discrepancy should be unimportant.

9. Griliches (1990) finds evidence of a strong relationship between R&D expenditure and patent numbers (see also Pavitt (1982) and Kortum (1997); and Trajtenberg (1990) who forwards an alternative viewpoint).

10. Looking ahead for a moment, we use the difference operator 'Δ' because we measure the variables in logs, so that the ratio of current to lagged GDP per capita becomes a change in (log) GDP per capita.

11. The black market exchange rate premium is computed as (BMR - OR)/OR, where BMR is the black market exchange rate and OR is the official exchange rate (both measured in local currency per US dollar).

12. Data on variables IP and EDU were in any case quinquennial.

13. Our OECD (Organisation for Economic Cooperation and Development) sample includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Iceland, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom and the United States. We do not include Mexico and Korea, because these joined the OECD as recently as 1994 and 1996, respectively.

14. One of the 'x-variables' is the instrumental variable PRDIHAT. We derived this variable using both the random effects and fixed effects specifications, but that made no difference to the estimation results for equation (2).

15. We must not, however, be doctrinaire about the model selection procedure, because theory is not well-defined enough to spell out either *the* complete model or *the* base model to start off with.

16. The regression results for equation (1), that is for the instrumental variable PRDIHAT, are

$$\underset{}{PRDI} = \underset{(0.702)}{0.126\, S_{t-1}} + \underset{(1.828)}{0.339\, \Delta GDPPC} + \underset{(1.818)}{0.531\, EDU} + \underset{(0.379)}{0.105\, ID} + \underset{(0.191)}{0.012\, BMPD} + \underset{(0.719)}{0.037\, RLR}$$

where the intercept coefficients have not been reported as there are too many. The t-statistics are given in parentheses. As mentioned in note 13, we estimated the instrumental variable using both the random effects and fixed effects specification, but that made no difference to the subsequent estimation results. The only reason we used the latter was the high correlation that this gave between PRDI and PRDIHAT (0.990).

17. The regression results for equation (1), that is for the instrumental variable PRDIHAT, are

$$PRDI = \underset{(1.270)}{0.244\, S_{t-1}} + \underset{(1.771)}{0.257\, \Delta GDPPC} + \underset{(0.256)}{0.031\, EDU} + \underset{(2.829)}{0.765\, ID} - \underset{(-4.021)}{0.462\, BMPD}$$

where the intercept coefficients have not been reported as there are too many. The t-statistics are given in parentheses. As mentioned in note 13, we estimated the instrumental variable using both the random effects and fixed effects specification, but that made no difference to the subsequent estimation results. The only reason we used the latter was the high correlation that this gave between PRDI and PRDIHAT (0.994).

18. The regression results for equation (1), that is for the instrumental variable PRDIHAT, are

$$PRDI = \underset{(0.948)}{0.170\, S_{t-1}} + \underset{(2.051)}{0.357\, \Delta GDPPC} + \underset{(0.774)}{0.367\, LIT} - \underset{(-0.476)}{0.093\, ID} + \underset{(0.105)}{0.006\, BMPD}$$

where the intercept coefficients have not been reported as there are too many. The t-statistics are given in parentheses. As mentioned in note 13, we estimated the instrumental variable using both the random effects and fixed effects specification, but that made no difference to the subsequent estimation results. The only reason we used the latter was the high correlation that this gave between PRDI and PRDIHAT (0.989).

19. The regression results for equation (1), that is for the instrumental variable PRDIHAT, are

$$PRDI = \underset{(3.120)}{0.788\, S_{t-1}} - \underset{(-3.279)}{0.637\, \Delta GDPPC} + \underset{(3.680)}{14.049\, LIT} + \underset{(1.888)}{0.088\, BMPD}$$

where the intercept coefficients have not been reported as there are too many. The t-statistics are given in parentheses. As mentioned in note 13, we estimated the instrumental variable using both the random effects and fixed effects specification, but that made no difference to the subsequent estimation results. The only reason we used the latter was the high correlation that this gave between PRDI and PRDIHAT (0.972).