Overseas R&D and the Intellectual Property Protection that Host Nations Provide

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Abstract

This paper investigates whether, in what direction, and to what extent, overseas R&D is influenced by the strength of intellectual property protection that host nations provide. Using data spanning the period 1977-2004, we find that stronger intellectual property rights are an insignificant determinant of overseas R&D, although there is evidence that the influence of the former variable on the latter may be stronger in developed than in developing countries. This result is found to be robust to dis-aggregation of both the measure of intellectual property protection into its component indices, as well as to dis-aggregation of overseas R&D by industry. Instead, the host country market size and availability of local human capital resources are found to be the consistently important explanatory variables.

JEL Codes: O34, O31
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1. The Larger Picture

Today innovation or technological change[1] is seen as a prime motive force behind economic growth.[2] The innovation in a given country may be conducted by domestic entities and/or foreign entities resident there. For many countries, the latter or the research and development activities of multinationals may be a notable source of both technology transfer as well as technology diffusion. Thus, Harrison (1994) avers that new technology may not always be available on the market via licensing arrangements; so that joint ventures with innovating multinationals may be the best means of learning new technology. Further, such tie-ups with foreign innovating firms may be the best source of certain forms of managerial human capital formation, with possible spillovers into the domestic economy. While this may be more likely in the case of developing countries (which have been net technology-importers), it may be true of developed countries as well (insofar as technical and scientific manpower moves between firms in developed countries too). To the extent that such spillovers are a more important mode of technology transfer and diffusion for developing countries (e.g. Javorcik 2004a, Poole 2008), it is a mode these countries are oftentimes exhorted to encourage (United Nations 1974).[3] Of the alternative instruments that exist to encourage multinational R&D and innovation, the strength of intellectual property protection in the host nation is arguably a potentially important one.[4] The use of the instrument of intellectual property protection, however, has been extremely vexed, as was demonstrated by the rather long drawn-out and bitter negotiations between the developing and developed countries before the agreement on Trade-Related Intellectual Property rights was inked in 1994.[5]

One of the prime concerns, needless to add, has been whether stronger protection does in fact spur domestic innovation. The empirical evidence in this regard has not been very helpful either. While Sakakibara and Branstetter (2001), and Lerner (2002) find that stronger protection does not stimulate innovation, Kanwar and Evenson (2003), and Chen and Puttitanum (2005) find that it does.

Even if the latter verdict is accepted, there is still not much clarity about which sectors of the economy would benefit the most from stronger protection. Mansfield (1986) and Levin et.al (1987) present somewhat impressionistic evidence based on surveys of R&D executives in various American industries, to show that while patent protection is considered overwhelmingly important in the pharmaceuticals and chemicals industries, it rates much lower in the protection of other industries. Qian (2007) concludes, that although domestic pharmaceutical patent protection does not stimulate domestic pharmaceutical innovation, domestic innovation does accelerate in countries with higher overall economics development. In her review of the available evidence, Hall (2007) adds software and biotechnology to this list. Empirical evidence also shows stronger protection to matter in the field of agriculture in general (Alfranca and Huffman 2003).[6]

Domestic innovation, however, is only part of the story. Stronger protection is also supposed to benefit technology transfer. None of the empirical studies cited in the previous paragraph consider this phenomenon. Of course, the transfer of technology is a complex process, and occurs through various means. Some of the more important channels appear to be trade, foreign direct investment, licensing, and overseas R&D by multinationals. Ferrantino (1993), Maskus and Penubarti (1995) and Smith (1999, 2001) provide evidence supporting the positive effect of stronger protection on trade. Similarly, Ferrantino (1993), Lee and Mansfield (1996), and Javorcik (2004b) find that stronger protection encourages foreign direct investment. McCalman (2004) shows that, in the context of certain industries, this relationship is likely to be non-linear. Both these forms of technology transfer are, however, indirect in nature.

The more direct modes of transfer are licensing, and overseas R&D.[7] Yang and Maskus (2001) find a *negative* relationship between intellectual property protection and licensing for indices of protection below a certain threshold, although above this threshold a positive relationship obtains. Branstetter, Fisman and Foley (2006) report weak results for the effect of stronger protection on intra-firm royalty payments – the index of protection dummy they use is statistically insignificant in four of the six regression reported (see their Table III, p. 336). Their results vis-à-vis overseas R&D investment are even weaker – the index of protection dummy being statistically insignificant in five of the six regressions reported (see their Table IV, p. 340).[8] Additionally, their analysis is limited to mostly developing countries, which account for a very small percentage of the total R&D investment undertaken by the majority-owned overseas affiliates of US firms. Thus, in 1999 (the end of their sample period), the countries in their sample accounted for just 16.2% of the total overseas R&D investment of the majority-owned foreign affiliates of US multinationals; and of this, about 8.4 percentage points was the share of Japan alone, implying that the remaining 15 countries accounted for less than 8% of the total overseas R&D investment in question. This raises questions about the general applicability of their results, leaving room for further work in this area.

Accordingly, our study focuses on this latter-most mode of technology transfer – namely, the overseas R&D investment by majority-owned foreign affiliates of US firms – and attempts to gauge whether, in what direction, and to what extent it is influenced by the strength of intellectual property protection that the host nations provide. In doing so, we consider all countries and all time-periods for which data are available, resulting in a sample of over forty countries spanning the substantially long period 1977-2004. We employ a carefully constructed index of patent rights, covering several important dimensions of patent protection. Robustness checks using the component indices underlying this index of protection, as well as disaggregation of overseas R&D by industry, are conducted. How the relationship in question varies across developed and developing nations is also analysed. Our analysis shows that the strength of protection was an insignificant determinant of overseas R&D by (US) multinationals, although the influence of such protection on overseas R&D was likely stronger in developed than in developing countries. Subsequent analysis shows this result to be robust to the possibility of aggregation bias both in the dependent variable as well as in the causal variable, and also simultaneity bias if any. Overseas R&D is found to respond significantly, instead, to variables such as the market size of recipient countries, and their stock of human capital. Section 2 fleshes out the basic estimation model of this paper, and extensions thereof. Section 3 provides some detailed information about the data employed. Section 4 discusses the estimation results. Section 5 deals with the possibility of endogeneity in the causal variable. And finally, section 6 briefly concludes.

2. Intellectual property protection and overseas R&D: The estimation model

We may conceptualise the issue at hand as follows. Consider a multinational with foreign affiliates in two different locations, e.g. two different countries, contemplating R&D investment in these locations. Whether the strength of intellectual property protection is a likely factor of interest to the multinational vis-à-vis this potential investment, will depend upon the size of the innovation resulting from the R&D investment undertaken. If the resulting innovation were significant enough, and hence marketable on its own, then the affiliate is likely to be concerned with issues of appropriability, in which case the strength of protection in a given location would matter; so that more R&D, ceteris paribus, would be conducted in locations offering stronger protection. If, alternatively, the size of the innovation resulting from such R&D were small and incremental, and therefore not marketable on its own, then the affiliate is not likely to be too concerned with matters of appropriability; so that the strength of protection in a given location in not likely to be an issue. Given that there is evidence to show that a lot of the innovation resulting from overseas R&D tends to be incremental in nature, i.e. it is undertaken to adapt the product to local needs and sensibilities (Mansfield, Teece and Romeo 1979), à priori the second possibility appears to be more probable – namely, a situation where overseas R&D by affiliates is not likely to be strongly related to the strength of intellectual property protection in the host nations. To test such a hypothesis we develop appropriate regression models in the following three sub-sections..

2.1 *The regressand: One mode of technology transfer*

The regressand in our estimation exercises is (the total)[9] overseas research and development investment undertaken by the (majority-owned) affiliates of US firms in a given country, as a proportion of the gross product of these affiliates (*RDPA*). A majority-owned foreign affiliate is one in which the direct and indirect ownership interest of a US parent(s) exceeds 50%; so that the latter may be presumed to exercise unambiguous control over the former. The R&D investment undertaken by the affiliates in a given country may, then, be causally related to various characteristic features of both those affiliates as well as that (host) country. Of course, this variable is an underestimate of the technology transfer involved insofar as it does not account for the subsequent spillover effects; however, there is no obvious way of remedying this.

2.2 *The causal variable*

The main regressor of interest or the 'causal variable' in our model is the strength of intellectual property protection in the host countries, i.e. the countries receiving R&D investment from US multinationals. This is represented by an index of patent rights or the Ginarte-Park index (*IPGP*), taken from Ginarte and Park (1997), and Park (2008). Their index employs objective criteria to manifest the strength of protection a nation provides. It considers several aspects of patent protection, which makes for greater variation in the index even for the developed countries. Specifically, it considers five aspects of patent laws – extent of coverage (i.e. the matter that can be patented), duration of protection (i.e. the number of years of protection), membership of international property rights agreements, [10] potential revocation of the patent rights once granted (e.g. through provisions such as compulsory licensing), and enforcement mechanisms available in different countries. For each of these five aspects a country receives a score ranging from 0 to 1, a larger score indicating stronger protection in that aspect, which yields five sub-indices – the index of coverage (*ICOV*), the index of duration (*IDUR*), the index of membership (*IMEM*), the index of potential revocation (*IREV*), and the index of enforcement (*IENF*). The overall Ginarte-Park index *IPGP* is computed as the aggregate of these five sub-indices, so that it ranges from 0 to 5, with higher values indicating stronger patent protection.[11]

2.3 *The control variables*

While the strength of intellectual property protection is the causal variable in our model, given that the 'treatment level' has not been randomly assigned across countries, we need to control for the other factors that influence overseas R&D by US multinationals. As mentioned above, research in this area shows that a lot of overseas R&D is undertaken to cater to the special design needs of the host markets (Mansfield, Teece and Romeo 1979). It is reasonable to argue that multinationals are likely to respond thus, only to the extent that the host market in question matters to them. Conversely, if the host country market is small, the multinationals are not likely to be sensitive to local requirements. The size of the host country market may, therefore, be used to represent this consideration for local/regional preferences. We use the host country sales[12] of the subsidiary (*SALES*) to proxy this complex factor.[13]

Internal funds are arguably very important for R&D investment in general (Hall 1992) and, presumably, for overseas R&D investment as well. While parent multinationals may earmark funds for their overseas subsidiaries, an important determinant of subsidiary R&D is likely to be the savings generated by the subsidiaries themselves. One reason why financial institutions are reluctant to lend for such purposes is the high risk of such investments; what return such investments are likely to fetch is highly uncertain. As a result, internal funds acquire a lot of importance. Using data on this variable obviates the need for separate data on variables such as host country corporate tax rates, because those would be implicit in the savings data.[14] We capture this variable (*INTFUNDS*) in terms of the net income of the majority-owned affiliates in various countries as a proportion of their gross product. Since the net income of affiliates is computed as gross revenue minus costs minus foreign taxes, it accounts for any R&D tax incentives that foreign governments give to the affiliates. Usually, R&D tax incentives allow the affiliates to pay taxes at some concessional tax rate (as compared to the rate at which they would have to pay if they did not conduct R&D). Thus, R&D tax incentives merely lower the affiliates' tax liability, and leave them with a higher net income.

Multinationals conduct R&D abroad to benefit from various local advantages that may obtain. Thus, the availability of abundant and well-qualified technical and scientific manpower in the host nation might be an attractor (Mansfield, Teece and Romeo 1979). Given the paucity of data on the stock of such manpower, however, we use the stock of human capital as a proxy. This human capital variable is defined as *ENROLLD* = 1 when the average gross enrollment rate in primary, secondary and tertiary education in the host country exceeds the median level for our sample of countries, in a given year, and equals 0 otherwise.

Openness of the host nation to trade and investment from abroad would be an important consideration in what R&D investment it attracts. While none of the competing measures of openness available in the literature are considered entirely satisfactory in this regard, we use the "freedom to trade" sub-index computed by Gwartney, Lawson and Norton (2008). This sub-index incorporates various aspects of trade openness such as taxes on international trade, regulatory trade barriers (including non-tariff barriers), black market exchange rates, as well as international capital market controls. We call it the trade openness index (*TOI*)., which ranges from 1 to 10, with higher values indicating freer trade.

The extent of economic freedom in the host country would be another factor of relevance to the magnitude of R&D investment it attracts. One would reckon that the more interventionist the government and the more controls it imposes on economic activity, the less attractive would be the market in question to foreign investors. We compute the economic freedom index (*EFI*) as the average of four sub-indices constructed by Gwartney, Lawson and Norton (2008) – specifically, the magnitude of government taxes, expenditure and enterprises, the legal structure and security of property rights, the access to sound money, and the regulation of credit, labour and business. Thus, we adapt their index of freedom by dropping their fifth sub-index 'freedom to trade', which was used to construct the trade openness variable discussed in the previous paragraph. This re-computed index varies from 1 to 10, with higher values implying greater economic freedom.

Putting these variables together, we intend to estimate relationships of the form:

$$\text{Ln } RDPA_t = f(\ln IPGP_t, \ln SALES_t, \ln INTFUNDS_t, \ln ENROLL_t, \ln TOI_t, \ln EFI_t) \qquad (1)$$

where all the variables have been described above. All regressions are estimated using time (or year) fixed effects, though with and without country fixed effects.[15] In this connection, it is true that the countries in our sample probably differ in a lot many respects (persistent over time) that are difficult to control for explicitly, necessitating the inclusion of country fixed effects. However, at least some of these differences probably pertain to various aspects of the strength of intellectual property protection, because the causal variable *IPGP* used in the regressions only captures certain specified aspects of patent rights; indeed, any such measure must perforce be partial in nature, if only on account of data limitations. Consequently, the remaining aspects of intellectual property protection would be picked up by the country fixed effects, despite the fact that these aspects are not actually constant over time. In other words, the fixed effects model is probably an 'over-correction', implying that we cannot dismiss the random effects model à priori.

An alternative specification also includes the interaction term $ln\ IPGP_t * GDPPCD_t$, where *GDPPCD* = 1 for countries with above-median *GDP* per capita in a given year, and equals 0 otherwise. Significance of this term would indicate that the response of overseas R&D to the strength of intellectual property protection differs significantly between developed and developing countries.

3. Data and Sources

The data pertaining to the majority-owned foreign affiliates of US multinationals are those collected by the Bureau of Economic Analysis (BEA) of the US Department of Commerce, for various 'benchmark survey years' (Bureau of Economic Analysis, various years). Benchmark surveys were conducted in 1966, 1977, 1982, 1989, 1994, 1999 and 2004, for the universe of US firms investing abroad. The published data, however, are country-level aggregates, i.e. for the sum total of the foreign affiliates (of US firms) in a given country, and these are the data we use. Given that data on many of the variables of interest to us are not available in the 1966 survey, we drop that survey from our basic data set.

The Ginarte-Park index of protection *IPGP* is available for all the years for which BEA data are available, roughly corresponding to the BEA survey years (Ginarte and Park 1977; Park 2008). Thus, we pair *IPGP* data for 1975, 1980, 1990, 1995, 2000 and 2005 with the BEA survey data for 1977, 1982, 1989, 1994, 1999 and 2004, respectively. Data on the other host country variables were taken from several different sources. The human capital data used to compute the average enrollment rate at the primary, secondary and tertiary levels (*ENROLLD*) were taken from World Development Indicators (WDI) (World Bank, various years). The trade openness index (*TOI*) and the economic freedom index (*EFI*) were both computed on the basis of data taken from Gwartney, Lawson and Norton (2008), as noted above. We might add, that for a small number of observations, although data on the regressand and the causal variable were available, data on some of the other regressors discussed above were missing, and so these observations had to be dropped.

The descriptive statistics presented in Table 1 pertain to the raw data or *un*transformed variables. A cursory examination of the table reveals that the strength of intellectual property protection as measured by *IPGP* rose substantially over the sample period, and so did the overseas R&D investment performed by the affiliates of the US multinationals. This, of course, does not establish any concrete causal relationship between these two variables, and for that we proceed to more formal analysis.

4. Intellectual property protection and overseas R&D: Estimation Results

We commence by noting that the pair-wise correlation coefficient between *RDPA* and *IPGP* is 0.34. The corresponding pair-wise correlation between the logarithms of these variables is even larger at 0.56. We get a similar picture from the scatter-plot of *RDPA* on *IPGP* (with the variables in logarithms), as is evident from Figure 1. Thus, the raw data suggest a fairly strong, positive relationship between overseas R&D investment by the affiliates of (US) multinationals and the strength of intellectual property protection that the recipient nations provide. How strong this relationship is empirically, and whether it is causal in nature are issues that we attempt to address in the following section.

Before discussing the regression results, however, we feel it would be useful to re-iterate an observation that we made above. To the extent that our sample countries (persistently) differ in ways other than what our control variables account for, the inclusion of country fixed effects might be in order. However, some of these differences across countries are likely to pertain to various aspects of the strength of intellectual property protection, because the ‘causal variable’ *IPGP* explicitly captures some specific aspects of patent rights only (see its definition above). In fact, any measure of protection (the causal variable) would be necessarily incomplete, if only due to data limitations, so that the remaining aspects of intellectual property protection would be picked up by the country fixed effects. In other words, the fixed effects model is probably an over-correction. Therefore, there is sufficiently strong reason to accept the random effects results, and consider the fixed effects results only as confirmatory evidence.

4.1 *R&D by overseas affiliates and intellectual property protection*

The results in Table 2 reveal, that the hypothesis that overseas R&D by the majority-owned foreign affiliates of US firms is randomly determined is strongly rejected, the *p*-value of the corresponding test being 0 in all the regressions. All regressions in the table include time or year fixed effects, and report heteroscedasticity and autocorrelation-consistent standard errors The random effects results in column (1) show that the intellectual property protection variable *IPGP* has an insignificant influence on overseas R&D. The addition of the interaction term *ln IPGP* GDPPCD* in the alternative regression in column (2) does not change this result. The fixed effects results reported in columns (3) and (4) augment those presented in columns (1) and (2) by including the country fixed effects. The introduction of country fixed effects does not alter the insignificance of the causal variable in explaining changes in overseas R&D.

Of the other regressors, the market size variable *SALES* is found to be positive and strongly significant in both the random effects regressions of columns (1) and (2), lending credence to the claim that market size is an important motivator of overseas R&D. A $1 million increase in sales is associated with a 30% increase in the regressand. So is human capital *ENROLLD* an important regressor, suggesting that multinationals do in fact carry out R&D overseas to tap the stock of human capital available there. Thus, in countries with above-median stock of human capital, the regressand is a little under 30% larger. Finally, the interaction term *ln IPGP*GDPPCD* in the column (2) results is strongly significant, indicating that the effect of the property rights variable on the regressand differs significantly between high-income (developed) and low-income (developing) economies; the former response being a shade over 55% larger than the latter. Of course, this by itself does *not* imply that the relationship between *IPGP* and the regressand is necessarily significant in either group of countries (and we shall have more to say on this later). The fixed effects regression results reported in columns (3) and (4) support these observations, barring the insignificance of the interaction term in column (4), with the caveat that these results are weaker overall.

The choice to express the dependent variable as overseas R&D as a proportion of gross product, was made to allow for the differing magnitudes of affiliate operations in different countries. Of course, if both R&D expenditure and other production related expenditure increase pari passu, the *share* of activity that is R&D may not go up, even if the *level* of R&D does. To take care of this, we repeat the above estimations with the dependent variable defined simply as the (total) overseas research and development investment undertaken by the (majority-owned) affiliates of US firms in a given country (*RD*). The results are reported in Table 3. Suffice it to note, that they are much the same as those discussed above using *RDPA* as the dependent variable and, therefore, need not be discussed here in detail. Briefly, the index of protection variable *IPGP* is quite insignificant in all the regressions, and it is the market size variable *SALES* which is consistently strongly significant. The human capital variable *ENROLLD* is found to have a significant positive coefficient in the random effects regressions in columns (1) and (2), and so is the interaction term *ln IPGP*GDPPCD* in column (2). The fixed effects regression results in columns (3) and (4) are much weaker, although in broad agreement with the random effects results just noted. In the subsequent analysis, we restrict ourselves to the use of *RDPA* as the dependent variable (rather than *RD*), because this does not appear to influence the results, and avoids repetition.

4.2 *R&D by overseas affiliates and intellectual property protection – standardized coefficients*

A better understanding of the coefficient magnitudes presented in Table 2, especially of the causal variable, may be obtained by converting them into standardized coefficients; for the elasticities as they stand are not necessarily comparable across regressors – after all, a 10% change in regressors of very different scales and distributions may represent very different implied movements in the distributions of those regressors. From the standardized coefficients reported in Table 4, we again find that *IPGP* has a very small effect on overseas R&D by affiliates. Thus, a one standard deviation increase in the index of protection variable (which would, for instance, take a country from the 25^{th} percentile to beyond the 75^{th} percentile of the distribution of this regressor), would raise overseas R&D by at most a mere 0.07 standard deviation units (which would barely budge the percentile position of the distribution of the regressand). Even the corresponding 95% confidence interval (–0.10, 0.24) indicates a very small effect. Further, the market size variable *SALES* turns out to have the largest influence on variations in the dependent variable, with a one standard deviation change in the former being associated with a 0.4 to 0.5 standard deviation change in the latter; followed in relative importance by the human capital variable *ENROLLD*.

4.3 *R&D by overseas affiliates and intellectual property protection – an alternative interpretation*

It may be argued that not just any increase in the strength of intellectual property protection is likely to matter for overseas R&D. Thus, an increase in the strength of protection may not matter at all if the higher level of protection is still 'too low', i.e. below some threshold. Similarly, an increase in the strength of protection may have only a marginal incremental effect if the strength of protection was already above some threshold to begin with. In other words, what may matter is an increase in the strength of protection from below some threshold to above the threshold. To test this hypothesis we re-define the Ginarte-Park index of protection as a binary variable *IPGPD*, which equals 1 if *IPGP* equals or exceeds the median level of protection in a given year, and equals 0 otherwise.[16]

Column (1) of Table 5 shows that the index of protection dummy *IPGPD* continues to have an insignificant effect on the dependent variable. The addition of the interaction term *IPGPD*GDPPCD* in the column (2) specification does not change the picture; although the positive and weakly significant coefficient of the interaction term indicates that the influence of the index of protection variable on the regressand is stronger in the developed countries than in the developing countries. The addition of country fixed effects, as in the column (3) and column (4) results, does not alter the picture in any significant manner. Of the other explanatory variables, again the market size variable *SALES*, and the human capital variable *ENROLLD* are strongly significant in both the random effects specifications of columns (1) and (2). The fixed effects results of columns (3) and (4) support these results. In other words, this alternative interpretation of the influence of a strengthening of protection is perfectly in line with our earlier results, which suggests an insignificant relationship between overseas R&D performed by the affiliates of US multinationals and the strength of protection offered by the host country.

Of course, it may still be argued that the threshold that we created – namely, the median level of protection – may still not be high enough; so that a robustness check of the above conclusion may be in order. Accordingly, we re-define the Ginarte-Park index dummy variable to equal 1 for those countries that fall in the top one-third of the distribution by level of protection in a given year, and equal 0 otherwise, and this new dummy variable is labeled *IPGPD2*.[17] To avoid repetition, the results presented in Table 6 are not discussed here in detail, for they support those described just above. The only difference is that the interaction term *IPGPD2*GDPPCD* is no longer significant, which is understandable in view of the upward revision of the protection threshold; for this pushes some of the richer developed countries below the threshold, mitigating the possibility of the *RDPA-IPGP* relationship differing significantly between the above-threshold ('developed') and below-threshold ('developing') countries. Given that the results presented in this sub-section using *IPGPD* and *IPGPD2* are in line with those presented previously using the continuous form of the 'treatment variable', namely *IPGP*, we revert to the latter in our subsequent exercises.

4.4 *R&D by overseas affiliates and components of intellectual property protection*

At this point we must take cognizance of the fact that the index of protection *IPGP* is a simple aggregation of five sub-indices, as explained in section 2.2, and it is possible that the results that we obtained above may have been biased on account of this aggregation procedure; for some aspects of the overall protection may be more important than other aspects. To allow for this relative variation across the sub-indices, we repeat the exercises of section 4.2 using *ICOV*, *IDUR*, *IMEM*, *IREV* and *IENF* in lieu of *IPGP*.[18] The random effects and fixed effects results for the 'full' model (i.e. including the interaction term) are presented in Table 7. Suffice it to note that all the results are in conformity with those that we reported above using the aggregate index of protection *IPGP*. To wit, none of the sub-indices of protection are found to have a significant influence on overseas R&D; rather, it is the market size variable *SALES*, and the human capital variable *ENROLLD*, that are strongly significant in the random effects specification. The fixed effects results are in conformity with these, except that they exhibit lower levels of significance. Further, the interaction terms *ln ICOV*GDPPCD*, *ln IDUR*GDPPCD* and *ln ENF*GDPPCD* are strongly significant in the random effects results of columns (1a), (2a) and (5a), but all the interaction terms in the fixed effects specifications are insignificant.

4.5 *R &D by overseas affiliates (disaggregated by industry) and intellectual property protection*

We would like to allow for the fact that the dependent variable is based on an aggregation of the overseas R&D expenditure across various industries, and that the results discussed above may be biased on account of this aggregation; for it is quite conceivable that the effect of a change in the level of protection may vary depending on the industry in question. Unfortunately, however, the country-by-industry disaggregation of the overseas R&D data comes with a couple of problems. Such disaggregated data are available only for the years 1994, 1999 and 2004; which immediately reduces the number of observations at our disposal by half. Further, for most manufacturing industries, a very large proportion of the entries are not reported (or zero).[19] Therefore, we are forced to restrict ourselves to overseas R&D in just one industry – the chemicals manufacturing sector, which comprises pharmaceuticals and medicines, basic chemicals, and other chemicals. Fortunately, this industry is considered to be amongst the most responsive to intellectual property protection. We label the dependent variable for this sector as *RDPAC*. Table 8 reveals that the results for this sector are no different from those that we found for overseas R&D in the aggregate. Thus, the random effects results in columns (1) and (2) again suggest that it is the market size variable *SALES* and the human capital variable *ENROLLD* which have a strongly significant influence on the dependent variable, rather than the index of protection. The fixed effects regression results in columns (3) and (4) support the insignificance of the causal variable *IPGP*, but are otherwise even weaker than in the results reported above in explaining variations in the regressand..

4.6 *R &D by overseas affiliates and intellectual property protection – developed and developing countries*

Although the interaction term *ln IPGP*GDPPCD* (and its variants in the various results presented above) was found to be mostly significant in the random effects specifications, that only indicates that the relationship between overseas R&D and the index of protection differs significantly across the developed and developing countries. It does not indicate, however, that this relationship is necessarily significant in the developed and developing countries per se. To test the latter hypothesis, we split the sample into two groups – the 'developed' countries or those with above-median GDP per capita in a given year, and the 'developing' countries or those with below-median GDP per capita in a given year – and use each sample separately for our estimation exercises. Of the results in Table 9, the most important from our viewpoint is that the index of protection variable is insignificant in both the developed and developing country regressions, supporting the results found above for the entire sample of countries. (At the same time, the coefficient of *ln IPGP* is much larger for developed countries than for developing countries, 0.391 compared to 0.242 in the random effects models of columns (3) and (1), respectively. This matches our observation about the interaction term in section 4.1.) The market size variable *SALES* is strongly significant, and the human capital variable *ENRLLD* weakly so, in the random effects specification of column (1), i.e. for developing countries. However, the fixed effects results continue to be poor as before; and so are the results for the developed countries; which is no surprise, however, given the reduced sample sizes on account of splitting the overall sample..

5. Intellectual property protection and overseas R&D: Lags and Endogeneity Issues

The literature on intellectual property cautions us that the index of protection may not be exogenous (Lerner 2002; Ginarte and Park 1997). Although the argument traditionally made is in a somewhat different context (that the relationship between domestic innovation and strength of protection may be bi-causal), a similar argument may be made in the present context as well. Specifically, countries that attract relatively higher levels of overseas R&D investment provide relatively stronger protection to intellectual property. Alternatively, there may be 'third factors' (such as political pressure) that push both overseas R&D as well as the strength of protection in an upward direction. It is very difficult to correct for this possibility given the lack of convincing instruments for the strength of intellectual property protection. In fact, one often feels that there's nothing called a perfect instrument.[20] Eschewing instrumental variable estimation, therefore, we adopt the following strategy to tackle the possibility of reverse causation in the present context.

We conduct a Sims (1972) type test wherein we regress *RDPA* on both contemporaneous and following period *IPGP* together. The results, presented in Table 10, are not particularly illuminating –

in column (1) the performance of contemporaneous and following period *IPGP* is similar, whereas in columns (3) and (4) the comparison of their magnitudes is vitiated by their opposite signs.

Although the results in Table 10 are not inconsistent with the contention that the causation runs from the index of protection to overseas R&D investment, to be on surer ground we re-do the exercises of section 4.1 using the index of protection variable lagged one period or $IPGP_{t-1}$. This procedure also accommodates the argument that firms require time to adjust to changes in the strength of protection, so that lagged *IPGP* would be the more appropriate causal variable. The results are summarized in Table 11, [21] and we find that as before the random effects specifications in columns (1) and (2) perform relatively better than the fixed effects results in columns (3) and (4). Both columns (1) and (2) show that the index of protection has an insignificant effect on the dependent variable. Of the control variables, again it is the market size variable *SALES*, and the human capital variable *ENROLLD* that are strongly significant; and so is the interaction term *ln IPGP*GDPPCD*. The fixed effects results of columns (3) and (4) more or less support these results, although they are much weaker. The results presented in this section support those presented in previous sections, in particular those in section 4.1. This is true not just in qualitative terms, but in quantitative terms as well. Thus, Table 11 shows that a $1 million increase in sales still increases the regressand by about 30%. Similarly, in countries with above-median levels of human capital the regressand is higher by just under 30%. And the influence of the protection variable on the regressand is stronger in developed countries by about 55%, as compared to this effect in developing countries. We found much the same effects in Table 2, as discussed in section 4.1 above, which implies quite forcefully that whatever bias there may be on account of the reverse causality is probably unimportant.

6. Rounding Up

In the literature on intellectual property, one comes across claims about the influence that the strength of intellectual property protection may have on several key economic phenomena. One such is the effect that intellectual property protection has on technology transfer via overseas R&D investment by multinationals. Our paper attempts to gauge the strength of this empirical relationship. Using panel data spanning the period 1977-2004, we find that stronger intellectual property rights have an insignificant effect on the magnitude of overseas R&D investment by (US) multinationals. Variations in overseas R&D are found to respond strongly, instead, to variables such as market size and, to a lesser extent, human capital. One implication of our results is, that a tightening of intellectual property rights by developing countries pursuant to the TRIPs agreement may not have any significant influence on overseas R&D into these countries, ceteris paribus. These countries may fare better in attracting overseas R&D, nevertheless, with an expanding stock of human capital and market size. Of course, this by itself does not call into question the overall utility of strengthening intellectual property rights, for that would also depend upon the extent to which stronger intellectual property rights affect the rate of domestic innovation and other key economic phenomena that they are claimed to influence.

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Appendix 1

In addition to *IPGP*, three other indices of protection are available in the literature. Mansfield's (1993) index of protection is based on the perceptions of a sample of major US firms, about how weak intellectual property protection was in 1991, in a given set of countries. Each firm was asked whether the protection in each of these countries was too weak to permit it to transfer its newest technology to a wholly-owned subsidiary there, to invest in joint ventures with local partners, and to license its newest technology to unrelated firms. The higher the percentage of firms that answered in the affirmative for a given country, the *weaker* the protection offered by that country. The *strength* of protection may, then, be measured as 100 minus this percentage. This index varies between 0 and 100 (mean 76.71; standard deviation 10.19), with higher percentages indicating stronger protection. Rapp and Rozek's (1990) index is based on a comparison of individual countries' patent laws with the guidelines proposed by the US Chamber of Commerce's Intellectual Property Task Force. Their index ranges from 0 to 5 (mean 3.41; standard deviation 1.48), with higher numbers indicating greater conformity with the proposed guidelines, and thereby signifying stronger protection. The World Economic Forum index, reported in its Global Competitiveness Report (World Economic Forum, various years), is based on the opinions of professionals, regarding the strength of protection in their respective countries. It is purportedly computed in this impressionistic manner precisely 'to capture what might not be reflected in official statistics'. It ranges from 0 to 10 (mean 6.35, standard deviation 1.59 for our sample period), with higher numbers signifying stronger protection.

The problem is that the effective sample sizes are merely 15 and 37 for the Mansfield and Rapp-Rozek indices, respectively; and because they are available for just a single year, fixed effects would not be feasible. Although these shortcomings do not characterise the World Economic Forum index, it is just as subjective as the other two. Moreover, it relates to the *overall* intellectual property climate in countries rather than *patent* rights only, and while this may appear to be a strength of the index at first sight, it may well be its weakness insofar as countries provide differing strengths of protection to different forms of intellectual property. Consequently, exercises based on these indices would be most unreliable (for example, Kumar 1996, who uses the Rapp-Rozek measure). Therefore, none of these three indices is suitable for further analysis in the present context.

Table 1: Descriptive Statistics for the data set – Means and Standard Deviations

Variable	Benchmark Year 1977	1982	1989	1994	1999	2004	Full period 1977-2004
Overseas Affiliates' Characteristics							
R&D expenditure	54.84	102.50	194.97	288.16	433.26	610.61	285.90
	(110.89)	(232.00)	(426.67)	(604.02)	(870.20)	(1142.04)	(695.61)
Gross Product	3415.35	5346.19	7578.15	9441.63	12974.70	17825.83	9559.78
	(5883.02)	(8887.82)	(12803.07)	(15011.72)	(20949.84)	(26914.72)	(17339.19)
Sales revenue	10367.22	16778.41	24071.65	33137.97	50464.45	71846.13	34979.47
	(17711.30)	(26333.00)	(40833.36)	(51560.97)	(75743.46)	(105398.40)	(64371.48)
Internal Funds	420.51	502.38	1597.88	1756.98	3368.75	7867.05	2640.06
	(694.53)	(814.44)	(2382.78)	(2247.11)	(5272.53)	(13348.34)	(6561.96)
Host Country Characteristics							
Enrollment (average)	61.10	64.35	66.78	73.19	79.05	83.07	71.48
	(11.91)	(10.67)	(10.70)	(13.01)	(14.84)	(13.32)	(14.69)
Trade Openness Index	6.09	6.65	6.90	7.39	7.77	7.49	7.07
	(1.56)	(1.40)	(1.42)	(1.09)	(0.93)	(0.83)	(1.34)
Economic Freedom Index	5.34	5.59	6.17	6.83	7.05	7.00	6.35
	(0.95)	(1.02)	(1.07)	(1.12)	(0.92)	(0.92)	(1.20)
Index of protection (Ginarte-Park)	2.06	2.34	2.56	3.37	3.93	4.07	3.08
	(0.85)	(1.01)	(1.21)	(1.04)	(0.73)	(0.59)	(1.20)
N	37	37	40	40	40	40	234

Note: *Un*transformed variables. Standard deviations in parentheses below corresponding means.
Units of variables are: R&D expenditure ($ million), Gross Product ($ million), Sales revenue ($ million), Internal funds ($ million), Enrollment (%), Trade Openness (index), Economic Freedom (index), Index of protection: Ginarte-Park (index).
The entire set of countries is: Argentina, Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Denmark, Egypt, Finland, France, Germany, Greece, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, New Zealand, Norway, Panama, Peru, Philippines, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, UK, Venezuela.

Table 2: The Effect of Intellectual Property Protection
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)
Ln IPGP	0.171	0.135	–0.174	–0.164
	(0.212)	(0.232)	(0.230)	(0.226)
Ln SALES	0.422***	0.312**	0.336**	0.326*
	(0.107)	(0.127)	(0.170)	(0.175)
Ln INTFUNDS	0.084	0.029	0.053	0.044
	(0.093)	(0.088)	(0.079)	(0.080)
ENROLLD	0.383***	0.272**	0.227*	0.231*
	(0.130)	(0.107)	(0.123)	(0.123)
Ln TOI	–0.268	–0.163	–0.150	–0.112
	(0.558)	(0.559)	(0.556)	(0.570)
Ln EFI	0.173	–0.103	0.078	0.041
	(0.576)	(0.573)	(0.596)	(0.515)
Ln IPGP * GDPPCD		0.558**		0.140
		(0.247)		(0.203)
Constant	–8.474***	–7.538***	–7.548***	–7.560***
	(1.020)	(1.092)	(1.325)	(1.321)
Year fixed effects	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes
Country fixed effects	No	No	Yes	Yes
P-value (year fixed effects = 0)	0.111	0.198	0.039	0.052
P-value (all slopes = 0)	0.000	0.000	0.000	0.000
Adjusted R^2	0.355	0.434	0.076	0.145
N	234	234	234	234

Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors.
***, ** and * denote significance at the 1%, 5% and 10% levels.

Table 3: The Effect of Intellectual Property Protection
Dependent variable – Ln RD

Regressor	(1)	(2)	(3)	(4)
Ln IPGP	0.078	0.035	–0.240	–0.228
	(0.197)	(0.217)	(0.226)	(0.222)
Ln SALES	1.341***	1.223***	1.255***	1.243***
	(0.104)	(0.126)	(0.166)	(0.171)
Ln INTFUNDS	–0.013	–0.077	–0.016	–0.027
	(0.076)	(0.081)	(0.070)	(0.070)
ENROLLD	0.385***	0.276**	0.158	0.164
	(0.131)	(0.116)	(0.128)	(0.128)
Ln TOI	–0.196	–0.080	–0.076	–0.029
	(0.538)	(0.541)	(0.564)	(0.574)
Ln EFI	–0.104	–0.418	–0.049	–0.095
	(0.539)	(0.546)	(0.544)	(0.542)
Ln IPGP * GDPPCD		0.603**		0.172
		(0.246)		(0.209)
Constant	–8.601***	–7.570***	–7.895***	–7.910***
	(0.978)	(1.082)	(1.336)	(1.341)
Year fixed effects	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes
Country fixed effects	No	No	Yes	Yes
P-value (year fixed effects = 0)	0.170	0.177	0.056	0.077
P-value (all slopes = 0)	0.000	0.000	0.000	0.000
Adjusted R^2	0.814	0.842	0.731	0.753
N	234	234	234	234

Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors.
***, ** and * denote significance at the 1%, 5% and 10% levels.

Table 4: The Effect of Intellectual Property Protection – Standardized (Beta) Coefficients
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)
Ln IPGP	0.071	0.056	–0.073	–0.068
	(0.088)	(0.097)	(0.096)	(0.094)
Ln SALES	0.497	0.368	0.396	0.385
	(0.126)	(0.150)	(0.200)	(0.207)
Ln INTFUNDS	0.065	0.022	0.041	0.034
	(0.072)	(0.068)	(0.061)	(0.062)
ENROLLD	0.142	0.101	0.084	0.086
	(0.048)	(0.040)	(0.046)	(0.046)
Ln TOI	–0.044	–0.027	–0.025	–0.019
	(0.092)	(0.092)	(0.092)	(0.094)
Ln EFI	0.026	–0.016	0.012	0.006
	(0.087)	(0.087)	(0.090)	(0.090)
Ln IPGP * GDPPCD		0.276		0.069
		(0.122)		(0.100)
Year fixed effects	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes
Country fixed effects	No	No	Yes	Yes
N	234	234	234	234

Note: Standardized Standard Errors reported in parentheses below the standardized regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors.

Table 5: The Effect of Intellectual Property Protection (Index of protection dummy)
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)
IPGPD	0.070	–0.391	–0.152	–0.532*
	(0.172)	(0.323)	(0.196)	(0.296)
Ln SALES	0.409***	0.391***	0.371**	0.389**
	(0.110)	(0.108)	(0.177)	(0.185)
Ln INTFUNDS	0.073	0.056	0.069	0.058
	(0.084)	(0.080)	(0.078)	(0.078)
ENROLLD	0.368***	0.356***	0.234*	0.251*
	(0.128)	(0.129)	(0.123)	(0.131)
Ln TOI	–0.181	–0.198	–0.261	–0.277
	(0.484)	(0.489)	(0.502)	(0.504)
Ln EFI	0.135	0.184	0.144	0.200
	(0.544)	(0.537)	(0.544)	(0.548)
IPGPD * GDPPCD		0.622*		0.524*
		(0.331)		(0.300)
Constant	–8.385***	–8.348***	–7.779***	–8.059***
	(1.023)	(1.012)	(1.375)	(1.438)
Year fixed effects	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes
Country fixed effects	No	No	Yes	Yes
P-value (year fixed effects = 0)	0.052	0.104	0.062	0.106
P-value (all slopes = 0)	0.000	0.000	0.000	0.000
Adjusted R^2	0.332	0.342	0.097	0.128
N	234	234	234	234

Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors.
*** denotes significance at the 1% level; ** denotes significance at the 5% level.

Table 6: The Effect of Intellectual Property Protection (Index of protection Dummy 2)
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)
IPGPD2	0.148	0.067	–0.008	0.080
	(0.202)	(0.309)	(0.221)	(0.310)
Ln SALES	0.392***	0.391***	0.346**	0.339**
	(0.107)	(0.107)	(0.172)	(0.170)
Ln INTFUNDS	0.069	0.067	0.065	0.067
	(0.082)	(0.081)	(0.078)	(0.077)
ENROLLD	0.356***	0.352***	0.226*	0.224*
	(0.124)	(0.125)	(0.120)	(0.120)
Ln TOI	–0.184	–0.174	–0.253	–0.265
	(0.486)	(0.490)	(0.498)	(0.504)
Ln EFI	0.130	0.124	0.135	0.142
	(0.545)	(0.543)	(0.559)	(0.561)
IPGPD2 * GDPPCD		0.102		–0.120
		(0.355)		(0.366)
Constant	–8.247***	–8.254***	–7.640***	–7.566***
	(1.018)	(1.024)	(1.394)	(3.396)
Year fixed effects	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes
Country fixed effects	No	No	Yes	Yes
P-value (year fixed effects = 0)	050	0.061	0.061	0.047
P-value (all slopes = 0)	0.000	0.000	0.000	0.000
Adjusted R^2	0.339	0.337	0.145	0.131
N	234	234	234	234

Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors.
***, **, and * denote significance at the 1%, 5% and 10% levels.

Table 7: The Effect of Intellectual Property Protection (Components of the Index of protection)
Dependent Variable – Ln RDPA

Regressor	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)	(5a)	(5b)
Ln ICOV	–0.411	–0.758								
	(0.613)	(0.635)								
Ln IDUR			0.709	–0.056						
			(0.916)	(0.837)						
Ln IMEM					–0.166	–0.664				
					(0.708)	(0.760)				
Ln IREV							–0.133	–0.424		
							(0.577)	(0.684)		
Ln IENF									–0.586	–0.699
									(0.447)	(0.481)
Ln SALES	0.330***	0.343*	0.356***	0.347**	0.339***	0.354*	0.373***	0.356**	0.320***	0.317*
	(0.126)	(0.180)	(0.120)	(0.174)	(0.126)	(0.187)	(0.120)	(0.175)	(0.124)	(0.169)
Ln INTFUNDS	0.019	0.038	0.053	0.068	0.018	0.031	0.049	0.068	0.003	0.012
	(0.078)	(0.076)	(0.086)	(0.081)	(0.083)	(0.081)	(0.083)	(0.079)	(0.082)	(0.078)
ENROLLD	0.311***	0.234**	0.303***	0.224*	0.327***	0.254*	0.323***	0.236*	0.316***	0.240*
	(0.133)	(0.120)	(0.108)	(0.122)	(0.117)	(0.133)	(0.111)	(0.129)	(0.118)	(0.128)
Ln TOI	0.022	–0.032	–0.261	–0.261	0.011	–0.112	–0.128	–0.238	0.054	–0.0001
	(0.544)	(0.531)	(0.524)	(0.530)	(0.498)	(0.550)	(0.514)	(0.543)	(0.492)	(0.528)
Ln EFI	–0.099	0.023	0.048	0.147	–0.111	–0.011	0.067	0.124	–0.061	0.069
	(0.551)	(0.575)	(0.601)	(0.604)	(0.569)	(0.574)	(0.545)	(0.562)	(0.544)	(0.565)
Ln ICOV * GDPPCD	1.211**	0.650								
	(0.540)	(0.561)								
Ln IDUR * GDPPCD			0.878**	–0.262						
			(0.448)	(0.166)						
Ln IMEM * GDPPCD					1.048	0.558				
					(0.546)	(0.572)				
Ln REV * GDPPCD							0.933	–0.057		
							(0.591)	(0.495)		
Ln ENF * GDPPCD									1.115**	0.623
									(0.499)	(0.444)
Constant	–7.800***	–7.762***	–8.317***	–7.537***	–7.832***	–7.697***	–8.137***	–7.631***	–7.815***	–7.706***
	(1.040)	(1.317)	(1.431)	(1.599)	(1.067)	(1.355)	(1.023)	(1.394)	(1.062)	(1.296)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
P-value (year fixed effects = 0)	0.061	0.056	0.099	0.082	0.137	0.115	0.071	0.055	0.021	0.021
P-value (all slopes = 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Adjusted R^2	0.396	0.191	0.423	0.061	0.401	0.179	0.368	0.085	0.390	0.194
N	234	234	234	234	234	234	234	234	234	234

Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors
***, **, and * denote significance at the 1%, 5% and 10% levels.

Table 8: The Effect of Intellectual Property (The Chemicals Industry)
Dependent variable – Ln RDPAC

Regressor	(1)	(2)	(3)	(4)
Ln IPGP	–0.339	–0.428	–0.909	–0.909
	(0.498)	(0.493)	(0.596)	(0.601)
Ln SALES	0.490***	0.429***	–0.385	–0.386
	(0.098)	(0.103)	(0.335)	(0.337)
Ln INTFUNDS	0.005	–0.019	–0.053	–0.053
	(0.176)	(0.176)	(0.228)	(0.230)
ENROLLD	0.789***	0.702***	0.399*	0.400*
	(0.261)	(0.245)	(0.225)	(0.226)
Ln TOI	–2.532*	–2.720*	0.211	0.219
	(1.497)	(1.506)	(1.665)	(1.680)
Ln EFI	0.486	0.251	3.951***	3.968**
	(1.098)	(1.071)	(1.520)	(1.551)
Ln IPGP * GDPPCD		0.282		–0.044
		(0.209)		(0.169)
Constant	–6.751***	–5.432**	–9.789***	–9.791**
	(2.294)	(2.651)	(4.521)	(4.563)
Year fixed effects	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes
Country fixed effects	No	No	Yes	Yes
P-value (year fixed effects = 0)	0.318	0.459	0.143	0.142
P-value (all slopes = 0)	0.001	0.000	0.000	0.125
Adjusted R^2	0.404	0.415	–0.535	0.188
N	113	113	113	113

Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors.
***, **, and * denote significance at the 1%, 5% and 10% levels.

Table 9: The Effect of Intellectual Property – Developed and Developing Countries
Dependent variable – Ln RDPA

	Developing Countries		Developed Countries	
Regressor	(1)	(2)	(3)	(4)
Ln IPGP	0.242	–0.122	0.391	–0.150
	(0.293)	(0.304)	(0.490)	(0.571)
Ln SALES	0.361**	0.299	0.239	0.524
	(0.163)	(0.250)	(0.179)	(0.329)
Ln INTFUNDS	0.089	0.086	–0.119	–0.100
	(0.104)	(0.094)	(0.162)	(0.159)
ENROLLD	0.325*	0.237	–0.038	0.165
	(0.184)	(0.200)	(0.195)	(0.183)
Ln TOI	–0.675	–0.441	1.329	1.625
	(0.707)	(0.714)	(0.822)	(1.007)
Ln EFI	0.225	0.049	–0.734	0.181
	(0.758)	(0.769)	(0.604)	(0.572)
Constant	–7.630***	–7.202***	–8.162***	–12.480***
	(1.235)	(1.417)	(2.159)	(3.346)
Year fixed effects	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes
Country fixed effects	No	Yes	No	Yes
P-value (year fixed effects = 0)	0.541	0.348	0.218	0.221
P-value (all slopes = 0)	0.012	0.079	0.000	0.000
Adjusted R^2	0.117	–0.275	0.183	–0.168
N	113	113	119	119

Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors.
***, **, and * denote significance at the 1%, 5% and 10% levels.

Table 10: The Effect of Contemporaneous vs. Following Period Index of Protection (Sims-type test)
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)
Ln $IPGP_t$	0.202	0.047	–0.163	–0.178
	(0.222)	(0.253)	(0.253)	(0.265)
Ln $IPGP_{t+1}$	0.238	0.256*	0.114	0.155
	(0.221)	(0.212)	(0.215)	(0.221)
Ln SALES	0.393***	0.261**	0.258	0.246
	(0.102)	(0.122)	(0.185)	(0.194)
Ln INTFUNDS	0.095	0.032	0.077	0.065
	(0.104)	(0.093)	(0.083)	(0.086)
ENROLLD	0.330**	0.138	0.140	0.144
	(0.149)	(0.128)	(0.167)	(0.167)
Ln TOI	–0.439	–0.379	–0.378	–0.326
	(0.551)	(0.553)	(0.562)	(0.590)
Ln EFI	0.063	–0.271	0.116	0.063
	(0.642)	(0.657)	(0.690)	(0.695)
Ln IPGP * GDPPCD		0.711***		0.209
		(0.272)		(0.310)
Constant	–7.915***	–6.662***	–6.622***	–6.663***
	(1.117)	(1.184)	(1.469)	(1.452)
Year fixed effects	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes
Country fixed effects	No	No	Yes	Yes
P-value (year fixed effects = 0)	0.142	0.086	0.024	0.024
P-value (all slopes = 0)	0.000	0.000	0.000	0.000
Adjusted R^2	0.388	0.469	0.193	0.109
N	190	190	190	190

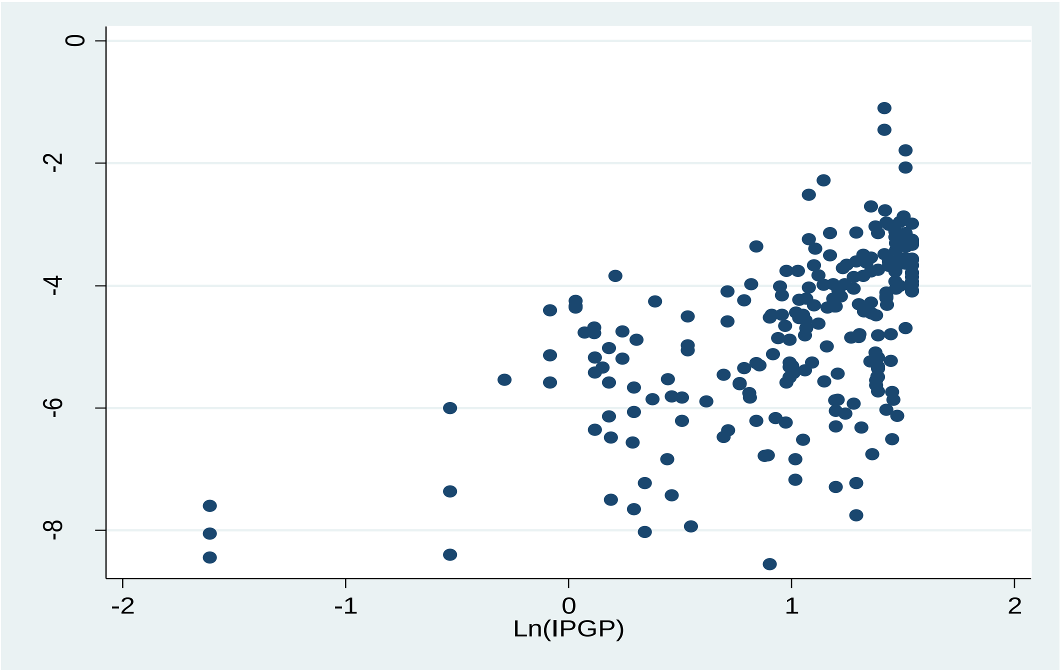
Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors
***, **, * denote significance at the 1%, 5%, and 10% levels.

Table 11: The Effect of Intellectual Property Protection (Index of protection lagged)
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)
Ln $IPGP_{t-1}$	0.099	0.039	–0.403*	–0.400*
	(0.173)	(0.203)	(0.234)	(0.236)
Ln SALES	0.420***	0.322***	0.337*	0.331
	(0.106)	(0.125)	(0.202)	(0.208)
Ln INTFUNDS	0.079	0.024	0.043	0.037
	(0.089)	(0.084)	(0.111)	(0.111)
ENROLLD	0.385***	0.290***	0.251*	0.252*
	(0.127)	(0.108)	(0.150)	(0.151)
Ln TOI	–0.203	–0.083	–0.123	–0.098
	(0.518)	(0.526)	(0.596)	(0.617)
Ln EFI	0.161	–0.062	–0.021	–0.038
	(0.571)	(0.562)	(0.634)	(0.636)
Ln $IPGP_{t-1}$ * GDPPCD		0.540**		0.080
		(0.252)		(0.262)
Constant	–8.517***	–7.763***	–7.317***	–7.335***
	(1.037)	(1.069)	(1.590)	(1.599)
Year fixed effects	Yes	Yes	Yes	Yes
HAC	Yes	Yes	Yes	Yes
Country fixed effects	No	Yes	No	Yes
P-value (year fixed effects = 0)	0.037	0.065	0.036	0.048
P-value (all slopes = 0)	0.000	0.000	0.000	0.000
Adjusted R^2	0.345	0.415	–0.060	–0.019
N	234	234	234	234

Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors.
***, **, and * denote significance at the 1%, 5% and 10% levels.

Figure 1: Scatterplot of *ln RDPA* against *ln IPGP*



Endnotes

[1] Strictly speaking, innovation pertains to the technology in existence whereas technological change pertains to the technology actually in use; but at the practical level this distinction does not help.

[2] This is not to deny the importance of other factors underlying growth. Thus, a growing body of recent research documents that, particularly in the case of developing countries, a reallocation of resources from less to more productive enterprises can drive productivity increases and growth (Pavcnik 2002; Hsieh and Klenow 2008). Such reallocation, however, is not likely to occur by itself, and probably requires policy-level innovations. While such innovation may not accord with the traditional definition of innovation, it is nevertheless a fact that certain countries (such as the US for example) allow the patenting of business methods.

[3] Of course, things might get more complicated in a dynamic context, insofar as a strengthening of intellectual property rights might have 'second round effects' in terms of changing proportions of direct investment, exports and licensing of technology. As this occurs, it will have its own implications for spillovers via imitation and other means.

[4] Some studies (for example, Davis 2004) aver that the 'original' objective of protection (to encourage innovation) has given way over time to other objectives (such as facilitation of strategic license-swaps), seeming to imply the diminishing influence of intellectual property protection in encouraging innovation. Similarly, Scotchmer (2004) adduces evidence to support the view that such protection probably ranks fairly low down the list of alternative means of protecting innovation. Nevertheless, one can still legitimately ask the question whether stronger protection (still) induces more innovation.

[5] Even so, the implementation was staggered over several years and, in the field of agriculture, many countries opted for a *sui generis* form of protection that is considered weaker than patent protection.

[6] A related but different question has to do with the distribution of the rents accruing from higher minimum protection, as under the TRIPs agreement. McCalman (2005, 2001) shows that although the

distribution of these benefits is likely to be skewed in favour of the developed countries, there is potential for all countries to benefit from this stronger protection.

[7] There is a substantial body of literature which studies the overseas R&D activities of firms, but does not consider how that R&D varies between countries in response to their strengths of intellectual property protection. For a useful survey see Granstrand, Hakanson and Sjolander (1993).

[8] If we restrict ourselves to their equations (1) and (4) (Table IV, p. 340), the protection dummy is insignificant in (4) and barely significant in (1). For the other four equations, they report that the positive effect of stronger protection is particularly true for firms which have high patent use – but this is a statement that the protection variable was *relatively stronger* for the high-patent-use firms than for the low-patent-use firms; it does not show that the effect of stronger protection per se was significant for either group of firms. The level of protection variable, as we have noted, was insignificant in five of their six regressions.

[9] The data available do not pertain to the overseas activity of each affiliate in a given country, but only to the sum total of affiliates in a given country. For further details see the data section below.

[10] In addition to membership of various intellectual property rights agreements, membership of the North-American Free Trade Agreement (NAFTA) is considered as well (see Park 2008); the implicit argument being that, for instance, Mexico would have to tighten its intellectual property laws courtesy its membership of NAFTA. We find this curious, because in principle at least, a similar case could be made about membership of other trade agreements as well, in manifesting the strength of protection a country provides. This would be problematic, because it is not clear which trade agreements have such an effect and which ones don't. It is not clear either, to what extent trade agreements have such an effect, assuming they do. Further, is this effect stronger for a country that is party to seven trade agreements as compared to one that is party to only six trade agreements?.

[11] In addition to *IPGP*, three other indices are available in the literature. Mansfield (1993) computes an index based on a 1991 survey of the perceptions of a sample of US firms, about the strength of protection in a set of mostly developing countries. Rapp and Rozek (1990) compute an alternative index based on the perceptions of the US Chamber of Commerce's intellectual property task force.

Both indices, however, are available for single cross-sections only, and are inappropriate for further analysis. The Global Competitiveness Reports (World Economic Forum, various years) provide an index based on surveys of the opinions and experiences of individuals, regarding the strength of intellectual property protection in their specific countries. Although available for several years of our sample, it is just as subjective as the previous two. For details, see Appendix 1.

[12] Of course, it is quite possible that a particular location (country) may be used to serve not just that market, but other markets as well. It would be possible to avoid this slippage, however, only if one had access to detailed information on the exact market jurisdictions of each 'hub'. Given the paucity of such data, we have to rest content with less ideal proxies.

[13] Alternatively, to jump ahead for a moment, we also tried the host country GDP and GDP per capita to represent its market size. Although the results were more or less in line with those using the sales variable, we preferred to use the sales variable because it yielded more consistent results. Moreover, GDP and GDP per capita also reflect many things other than market size.

[14] Ideally one would also like to account for any other taxes such as withholding taxes on company profits. Such data, however, are not available.

[15] It is true that the countries in our sample probably differ in a lot many respects (persistent over time) that are difficult to control for explicitly, necessitating the inclusion of country fixed effects. However, at least some of these differences probably pertain to various aspects of the strength of intellectual property protection, because the 'causal variable' *IPGP* only captures certain specified aspects of patent rights; indeed, any such measure must perforce be partial in nature, if only on account of data limitations. Consequently, the remaining aspects of intellectual property protection would be picked up by the country fixed effects, so that the fixed effects model is probably an over-correction. Therefore, there are strong grounds for considering the random effects model as well.

[16] The median levels of the index of protection *IPGP* corresponding to the survey years 1977, 1982, 1989, 1994, 1999 and 2004 were 2.25, 2.33, 2.71, 3.47, 4.01 and 4.18, respectively.

[17] The levels of the index of protection *IPGP* separating the top one-third of the countries from the bottom two-thirds, corresponding to the survey years 1977, 1982, 1989, 1994, 1999 and 2004, were 2.60, 2.95, 3.31, 4.15, 4.28 and 4.31, respectively.

[18] Data on the sub-indices *ICOV*, *IDUR*, *IMEM*, *IREV* and *IENF* were made available to us by Walter Park, Department of Economics, American University.

[19] Not only does this drastically reduce the degrees of freedom, it would also require the estimation of truncated regression models, for which fixed effects estimators are not feasible.

[20] The well-known textbook example of 'weather' being an 'ideal' instrumental variable for identifying an agricultural demand curve is a case in point (see Stock and Watson, 2007). The authors claim that rainfall does not have a direct influence on demand and, therefore, satisfies the condition of instrument exogeneity. Rainfall would affect not just a farmer's supply, however, but also his demand, insofar as his income depends on what he sells. If one is considering the rural economy only, or if one is considering a situation where the rural economy dominates the economy as a whole, then rainfall does not necessarily satisfy the condition of instrument exogeneity.

[21] We do not lose any observations on account of using the lagged regressor $IPGP_{t-1}$, because data on the lagged (pre-sample) values of *IPGP* (i.e. values before the starting year of our sample 1977) were available.