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INTELLECTUAL PROPERTY PROTECTION AND TECHNOLOGY TRANSFER THE CASE OF OVERSEAS R&D

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Abstract

This paper investigates whether, in what direction, and to what extent one mode of technology transfer – namely, 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 weak support at best for the claim that strengthening intellectual property rights will have a significant positive influence on the magnitude of overseas R&D investment by (US) multinationals. 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 into industry-specific magnitudes. 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). 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.[3] The use of the instrument of intellectual property protection, however, has been extremely vexed. It was only after rather long drawn-out and bitter negotiations between the developing and developed countries that the agreement on Trade-Related Intellectual Property rights was inked in 1994. The actual implementation of the agreement, however, took several more years, with many developing countries amending their domestic intellectual property protection laws only by the very fag end of 2004, the end of their implementation period. And even so, in the field of agriculture, many countries opted for a *sui generis* form of protection that is considered weaker than patent protection.

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).[4]

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.[5] Yang and Maskus (2001), and Branstetter, Fisman and Foley (2006) report that stronger protection does in fact stimulate technology transfer as measured by royalties and license fees. Note, however, that an increase in royalty and license fees could be entirely on account of an increase in the *cost* of technology transfer (i.e. the 'price' of the license so to speak), and does not necessarily imply an increase in the number of (new) licenses per se. Further, Branstetter, Fisman and Foley (2006) report rather weak results regarding the effect of stronger protection on overseas R&D investment – the index of protection dummy they use is statistically insignificant in five of the six regressions reported (see their Table IV, p. 340).[6] 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. Obviously, this would lead us to question the general applicability of their results.

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 for which such (and other relevant) data are available, and do not limit the set of countries to just the developing or the developed. Nor does our analysis employ an index of protection measure that is episode-specific or country-specific. Using alternative measures of the strength of intellectual property protection over the period 1977-2004, our analysis shows that the strength of protection was probably an insignificant determinant of (at least this mode of) technology transfer. Subsequent analysis shows this result to be robust to the possibility of simultaneity bias, if any. 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 'treatment variable'. And finally, section 6 briefly concludes.

2. The Estimation Model

2.1 *One mode of technology transfer*

The regressand in our estimation exercises is (the total)[7] 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 *Factors which might explain such technology transfer*

2.2.1 *The 'treatment variable'*

The main regressor of interest or the 'treatment 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. Since this variable is of major interest, we use two different indices of this variable available in the literature; although for various reasons that we will make clear, the second index is relatively preferable. The first index that we employ is one that is reported by the World Economic Forum in its Global Competitiveness Report (World Economic Forum, various years). This index (*IPWEF*) is based on surveys of the opinions and experiences of individuals, regarding the strength of intellectual property protection in their specific countries. It is purportedly computed in this impressionistic manner precisely 'to capture what might not be reflected in official statistics'. It relates to the *overall* intellectual property climate in countries, as opposed to the Ginarte-Park index (discussed next) which focuses on *patent* rights only. While this may appear to be a strength of this index at first sight, it may well be its weakness insofar as countries provide differing strengths of protection to different forms of intellectual property.

The second index we use is taken from Ginarte and Park (1997), and Park (2008). Their index is superior to that of the World Economic Forum, in that it is not based on subjective or ad hoc perceptions; on the contrary, it 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, [8] 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. Not only is it computationally superior to the previous index *IPWEF*, it is also available for a larger set of countries and a larger number of time periods. The coefficient of correlation between the World Economic Forum index and the Ginarte-Park index is 0.71.[9]

2.2.2 *The control variables*

While the strength of intellectual property protection is the 'treatment 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. 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[10] of the subsidiary (*SALES*) to proxy this complex factor.

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 component 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.[11] 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. The latter is defined as the average gross enrollment rate in primary, secondary and tertiary education in the host country (*ENROLL*).

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.

3. Data Issues

3.1 *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 World Economic Forum index of protection *IPWEF* is available for 1989, 1994, 1999 and 2004, and we pair these data with the 1989, 1994, 1999 and 2004 BEA survey data. 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. 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 (*ENROLL*) 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 'treatment variable' were available, data on some of the other regressors discussed above were missing, and so these observations had to be dropped. In the regression exercises, all variables are defined in logarithms, except the binary variables.

3.2 *Outlining the sample*

The descriptive statistics presented in Table 1 pertain to the sample data used with the Ginarte-Park index of protection, because this data set was available for the largest set of countries and the longest time period. The descriptive statistics in question pertain to the raw data or *un*transformed variables. In addition, summary statistics regarding *IPWEF* are also provided. A cursory examination of the table reveals that the strength of intellectual property protection as measured by *IPGP* (as well as *IPWEF*) 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.

We commence by considering the simple correlation coefficients between overseas R&D investment performed by the affiliates, and each of the alternative indices of protection. The pair-wise correlation coefficients between *RDPA* on the one hand, and *IPWEF* and *IPGP* on the other are, respectively, 0.33, and 0.34. The corresponding pair-wise correlations between the logarithms of these variables are even larger at 0.58, and 0.56. We get a similar picture from the scatter-plots of *RDPA* on each of the indices of protection (with the variables in logarithms), as is evident from Figure 1. Thus, the raw data for both measures suggest a fairly strong, positive relationship between overseas R&D investment by the affiliates of (US) multinationals and the strength of intellectual property protection. How strong this relationship is empirically, and whether it is causal in nature are issues that we attempt to address in the following section.

4. Estimation Results

4.1 *R&D performed by affiliates and intellectual property protection (World Economic Forum index)*

The intellectual property protection variable reported by the Global Competitiveness Report of the World Economic Forum, is available for various countries for four of the years for which BEA data are available on the overseas R&D investment of US firms – namely 1989, 1994, 1999 and 2004. Consequently, we have a respectable-sized panel for use with this measure of intellectual property *IPWEF*. From the results presented in Table 2 we find that the hypothesis that all regressors are identically zero is strongly rejected at the 1% level, the *p*-value of the associated test being 0.000 for all the regressions. The regression results in column (1) reveal that the index of protection variable *IPWEF* is positive and strongly statistically significant in explaining variations in technology transfer. When we add the control variables, as in the column (2) regression, variable *IPWEF* continues to be strongly significant, although its coefficient estimate drops substantially in numerical magnitude. Of the other regressors, the market size variable *SALES* is also positive and highly significant. When we add the year fixed effects, as in the column (3) regression, the index of protection variable and the market size variable continue to be positive and strongly significant. An F-test of exclusion restrictions on the year fixed effects is strongly rejected. When we further allow for the presence of a non-scalar error variance-covariance matrix, as in the 'full' random effects specification presented in column (4), we still find the index of protection to be positive and very strongly significant. So also is the market size variable *SALES*. Note also that the coefficient of the protection variable in regressions (2), (3) and (4) stabilizes around 1.1, and is associated with a 95% confidence interval with a lower limit of approximately 0.25-0.30 and an upper limit of about 1.9-2.0, indicating a high probability of a 'large' positive effect of a change in the index of protection on the regressand. These results are subjected to serious doubt, however, when we add the country fixed effects as in regression (5). The index of protection variable continues to be positive, and appears to approach significance using a one-tail test, although it halves in magnitude to about 0.6. The associated 95% confidence interval now becomes (–0.3, 1.5), which while implying a high probability of a substantial positive effect of the treatment variable on the regressand, leaves enough room for the possibility of an insignificant effect as well.

4.2 *R&D performed by affiliates and intellectual property protection (Ginarte-Park index)*

The Ginarte-Park index of protection is available for all the years for which BEA data are available on overseas R&D by US firms – namely 1977, 1982, 1989, 1994, 1999 and 2004. Consequently, we have the largest sample for use with this measure of intellectual property. Table 3 reveals, 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. The column (1) regression suggests that the intellectual property protection variable *IPGP* has a strong and large positive effect on technology transfer. The addition of the control variables in regression (2), however, reduces the positive effect of this regressor to almost a fifth of its previous value, and renders it insignificant. Of the other regressors, the market size variable *SALES* is found to be positive and very strongly significant. The further addition of the time fixed effects, as in the column (3) results, leaves the earlier result vis-à-vis the index of protection variable virtually the same. The *SALES* variable too remains positive and very strongly significant. In addition, the human capital variable *ENROLL* now also has a strongly significant positive influence on overseas R&D. Using heteroscedasticity and autocorrelation-consistent standard errors, as in the 'full' random effects regression of column (4), all the results of the previous regression remain unchanged, with the caveat that the human capital variable is now somewhat more weakly significant. An F-test of the significance of the time fixed effects recommends their inclusion at the 10% level. Finally, inclusion of the country fixed effects in regression (5) does not alter the insignificance of the protection variable *IPGP*; the market size variable *SALES* is the one that exercises a positive and significant effect on the regressand. Further, the joint significance of the time dummies seem to indicate that forces such as the globalization of world trade and investment pre-dating the WTO might also be responsible for the increase in overseas R&D by multinationals.

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 4. 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 in detail. Briefly, the index of protection variable *IPGP* is quite insignificant in all the regressions (barring the first, where it is the lone regressor), and it is the market size variable *SALES* which is consistently strongly significant. Also, the human capital variable *ENROLL* is found to have a significant positive coefficient in some of the regressions. 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.

4.3 *R&D performed by affiliates and intellectual property protection – standardized coefficients*

Although we have noted clearly the relative strengths of the Ginarte-Park measure of protection and, therefore, our preference for the estimation results using this measure, presentation of the results for the alternative measure *IPWEF* makes it natural for the reader to want to be able to compare the coefficient magnitudes across specifications. The elasticities, however, are not necessarily comparable – a 10% change in protection measures of very different scales and distributions across countries, may represent very different implied movements in the distribution of patent protection. To enable such comparison for those who might be interested, we compute standardized coefficients of the ‘treatment variable’, using the ‘full’ specification results (random effects and fixed effects) for both measures of protection, i.e. columns (4) and (5) of Tables 2 and 3. From the standardized coefficients reported in Table 5, we again find that *IPGP* has a very small effect on the overseas R&D by affiliates. Thus, a one standard deviation increase in the index of protection (which would, for instance, take a country from the 25th percentile to the 75th percentile), would raise overseas R&D by a mere 0.066 to 0.077 standard deviation units (depending on whether we use the random effects or fixed effects results, respectively). Even the 95% confidence intervals for these standardized coefficients, (–0.10, 0.23) for the random effects coefficient and (–0.26, 0.11) for the fixed effects coefficient, indicate the possibility of an economically insignificant effect.

4.4 *R&D performed by 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. Thus, an increase in the strength of protection may not matter at all (for overseas R&D, in the present context) 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.[12] We prefer to work with the Ginarte-Park index because of the various advantages it has over the alternative index, as pointed out above.

Column (1) of Table 6 shows that the index of protection dummy *IPGPD* has a large, positive and strongly significant effect on the dependent variable. Addition of the control variables, however, reduces the coefficient of the protection variable by almost a third and renders it statistically insignificant. As the column (2) results reveal, it is the market size variable *SALES* that is very strongly significant, with the human capital variable *ENROLL* mildly significant using a one-tail test. When we add the year fixed effects, as in the column (3) regression, the protection variable reduces further in size and significance; whereas the market size and human capital variables become even more strongly significant. Correction for heteroscedasticity and autocorrelation, as in column (4), does not alter these results. The addition of country fixed effects, as in the column (5) regression, also yields similar results, in that the protection variable is highly insignificant, whereas the market size variable is strongly significant. F-tests reject the exclusion of the year fixed effects from both the random effects and the fixed effects regressions of columns (4) and (5). In other words, this alternative interpretation of the influence of a strengthening of protection is perfectly in line with our earlier results, which suggest a very weak relationship at best between technology transfer as measured by 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; which is labeled *IPGPD2*.[13] To avoid repetition, the results presented in Table 7 are not discussed here, for they fully support those described just above. 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.

4.5 *R&D performed by 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 2.2.1, 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*.[14] Instead of reporting all the regression results for each of these sub-indices, only the random effects and fixed effects results for the 'full' model are presented in Table 8. 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* that is strongly significant and, to a lesser extent, the human capital variable *ENROLL*.

4.6 *R &D performed by affiliates (disaggregated by industry) and intellectual property protection*

Finally, 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 either zero or not reported.[15] 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 9 reveals that the results for this sector are no different from those that we found for overseas R&D in the aggregate, except for the fixed effects regression reported in column (5). Thus, it is the market size variable *SALES* and the human capital variable *ENROLL* which appear to have a significant influence on the dependent variable.

5. Endogeneity of the 'treatment variable'

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.[16] Eschewing instrumental variable estimation, therefore, we adopt the following strategy to gauge the possibility of reverse causation in the present context.

First we estimate a series of regressions wherein we regress the dependent variable *RDPA* on contemporaneous and following period values of the index of protection *IPGP* individually. The regression results presented in Table 10, however, are somewhat confounding. In regressions (1a) and (1b) the coefficient estimates, t-statistics, and summary statistics are substantially better for the former which uses the contemporaneous index of protection variable *$IPGP_t$*, as compared to the latter which uses the following period index *$IPGP_{t+1}$*. When the control variables are added, as in regressions (2a) and (2b), the verdict remains the same. In regressions (3a) and (3b) that include year fixed effects, and regressions (4a) and (4b) that allow for robust standard errors, however, there's little to choose between the regressions with the contemporaneous index of protection and those with the following period index; although technically the coefficients of the protection variable in the latter are mildly better, the goodness of fit is better in the former. Finally, allowing for country fixed effects, as in regressions (5a) and (5b), comparison is vitiated by the opposite signs of the coefficients of the index of protection variable.

Next we conduct a Sims (1972) type test wherein we regress *RDPA* on both contemporaneous and following period *IPGP* together. The results presented in Table 11 reflect much the same picture as the one outlined in the previous paragraph. In the column (1) and column (2) regressions, again we find that the performance of contemporaneous *IPGP* is substantially better. However, with the addition of the year fixed effects in column (3), and robust standard errors in column (4), the performance of both contemporaneous and following period *IPGP* is quite similar, with the latter marginally better. With the addition of the country fixed effects in column (5), comparison is vitiated by the opposite signs of the protection variable coefficients.

Putting together the results of both these causality investigations, we feel that these results are not inconsistent with the contention that the causation probably runs from the index of protection to overseas R&D investment, rather than vice versa. To be on surer ground, however, we re-do the exercises of section 4.2 using lagged values of the index of protection variable *IPGP*. The results are presented in Table 12. While column (1) shows that the index of protection has a positive, significant effect on the dependent variable, this result vanishes with the addition of control variables, as in column (2). The market size variable *SALES*, and the human capital variable *ENROLL* however, are strongly significant. This result becomes more pronounced with the addition of the year fixed effects in column (3), and correction for a non-scalar error variance-covariance matrix in column (4). Only with the addition of the country fixed effects in column (5), do the market size and human capital variable become only mildly significant using one-tail tests. These results support those that we presented in earlier sections, implying that whatever bias there may be on account of the reverse causality is probably unimportant.[17]

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 cross-country panel data spanning the period 1977-2004, we find weak support at best, for the claim that stronger intellectual property rights has any sizable effect on the magnitude of overseas R&D investment by (US) multinationals. Although we find a positive relationship between these two variables alone, and this result persists upon the addition of control variables, this positive relationship disappears when we introduce year fixed effects and country fixed effects into the regression. The associated 95% confidence intervals, though, do allow some room for a reasonable positive effect. Variations in overseas R&D are found to respond strongly, on the contrary, 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 technology transfer via overseas R&D into these countries, ceteris paribus. These countries may fare better, alternatively, 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 other key economic phenomena that they are claimed to influence.

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Appendix 1

As noted above, in addition to *IPWEF* and *IPGP*, two other indices of protection are available in the literature. Mansfield's (1993) index of protection is based on the perception 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. We can, therefore, measure the *strength* of protection as 100 minus this percentage. This index (*IPM*) 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, in its *Guidelines for Standards for the Protection and Enforcement of Patents*. Their index (*IPRR*) 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 problem, however, is that the Mansfield index of protection *IPM* is available for just 1991, and the Rapp-Rozek index *IPRR* for 1990 only, making for effective sample sizes of merely 15 and 37, respectively. Further, no year or country fixed effects can be introduced into the regressions if one were to use these indices. Consequently, any exercises based on these indices would be most unreliable (for example, Kumar 1996). Therefore, neither of these indices is suitable for further analysis in the present context.

Appendix 2

Even though the alternative protection variable employed in section 4.1 (*IPWEF*) was considered deficient in its construction, we re-do those exercises using lagged *IPWEF*, to take care of possible endogeneity of the protection variable. The results, reported in Table A2.1, are perfectly in line with those presented in Table 12 using lagged *IPGP*. Very briefly, the ‘full’ random effects and fixed effects regressions of columns (4) and (5) reveal that the protection variable $IPWEF_{t-1}$ has an insignificant effect on overseas R&D, and it is the market size variable *SALES* and the human capital variable *ENROLL* that are important explanatory variables.

Table 1: Descriptive Statistics for the data set

Variable	Benchmark Year 1977	1982	1989	1994	1999	2004	Full period 1977-2004
Overseas Affiliates' Characteristics							
RD	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)
GP	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	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)
INTFUNDS	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							
ENROLL	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)
TOI	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)
EFI	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)
IPGP	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
IPWEF			5.48	6.06	6.92	6.65	6.35
			(1.36)	(1.62)	(1.40)	(1.63)	(1.59)
N			28	35	39	40	142

Note: The variables are *un*transformed.
Standard deviations are given in parentheses below the corresponding means.
The units of these variables are: RD ($ million), GP ($ million), SALES ($ million), INTFUNDS ($ million), ENROLL (%), TOI (index), EFI(index), IPGP (index), IPWEF (index).

Table 2: The Effect of Intellectual Property Protection (World Economic Forum Index)
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)	(5)
Ln IPWEF	1.868***	1.067**	1.115**	1.115***	0.579
	(0.291)	(0.423)	(0.442)	(0.408)	(0.454)
Ln SALES		0.286***	0.436***	0.436***	0.403
		(0.100)	(0.119)	(0.167)	(0.399)
Ln INTFUNDS		–0.082	0.057	0.057	0.047
		(0.140)	(0.149)	(0.167)	(0.258)
Ln ENROLL		0.373	0.880	0.880	0.684
		(0.641)	(0.704)	(0.807)	(1.087)
Ln TOI		0.119	0.080	0.080	–0.041
		(0.742)	(0.742)	(1.070)	(1.194)
Ln EFI		–0.283	–0.623	–0.623	–0.111
		(0.812)	(0.809)	(0.969)	(1.248)
Constant	–7.949***	–10.680***	–13.504***	–13.504***	–12.217**
	(0.550)	(2.377)	(2.935)	(3.627)	(6.495)
Year fixed effects	No	No	Yes	Yes	Yes
HAC	No	No	No	Yes	Yes
Country fixed effects	No	No	No	No	Yes
P-value (year fixed effects 0)			0.047	0.003	0.044
P-value (all slopes 0)	0.000	0.000	0.000	0.000	0.000
$\bar{R}^2$	0.336	0.392	0.394	0.394	0.363
N	142	142	142	142	142

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 (Ginarte-Park Index)
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)	(5)
Ln IPGP	0.636***	0.137	0.158	0.158	–0.184
	(0.109)	(0.163)	(0.171)	(0.203)	(0.227)
Ln SALES		0.312***	0.422***	0.422***	0.340*
		(0.078)	(0.086)	(0.105)	(0.175)
Ln INTFUNDS		0.048	0.082	0.082	0.050
		(0.072)	(0.077)	(0.088)	(0.080)
Ln ENROLL		0.621	1.206**	1.206*	0.582
		(0.521)	(0.554)	(0.671)	(0.720)
Ln TOI		–0.267	–0.288	–0.288	–0.153
		(0.378)	(0.383)	(0.588)	(0.583)
Ln EFI		–0.063	0.060	0.060	0.015
		(0.427)	(0.447)	(0.586)	(0.593)
Constant	–5.388***	–9.755***	–12.973***	–12.973***	–9.724***
	(0.174)	(1.891)	(2.247)	(2.830)	(3.425)
Year fixed effects	No	No	Yes	Yes	Yes
HAC	No	No	No	Yes	Yes
Country fixed effects	No	No	No	No	Yes
P (year fixed effects 0)			0.011	0.062	0.046
P (all slopes 0)	0.000	0.000	0.000	0.000	0.000
$\bar{R}^2$	0.308	0.329	0.347	0.347	0.233
N	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 4: The Effect of Intellectual Property Protection (Ginarte-Park Index)
Dependent variable – Ln RD

Regressor	(1)	(2)	(3)	(4)	(5)
Ln IPGP	1.836***	0.043	0.051	0.051	–0.242
	(0.167)	(0.159)	(0.167)	(0.193)	(0.224)
Ln SALES		1.244***	1.342***	1.342***	1.255***
		(0.077)	(0.085)	(0.105)	(0.171)
Ln INTFUNDS		–0.032	–0.017	–0.017	–0.021
		(0.071)	(0.075)	(0.077)	(0.074)
Ln ENROLL		0.656	1.131**	1.131*	0.190
		(0.511)	(0.549)	(0.604)	(0.667)
Ln TOI		–0.246	–0.208	–0.208	–0.072
		(0.368)	(0.374)	(0.570)	(0.588)
Ln EFI		–0.228	–0.212	–0.212	–0.086
		(0.417)	(0.437)	(0.551)	(0.545)
Constant	1.455***	–10.198***	–10.815***	–10.815***	–8.539**
	(0.319)	(1.850)	(2.231)	(2.648)	(3.377)
Year fixed effects	No	No	Yes	Yes	Yes
HAC	No	No	No	Yes	Yes
Country fixed effects	No	No	No	No	Yes
P (year fixed effects 0)			0.021	0.143	0.064
P (all slopes 0)	0.000	0.000	0.000	0.000	0.000
$\bar{R}^2$	0.357	0.803	0.810	0.810	0.772
N	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 5: The Effect of Intellectual Property Protection – Standardized Coefficients
Dependent variable – Ln RDPA

	Treatment Variable			
	Ln IPWEF (Table 2, col. 4)	Ln IPWEF (Table 2, col. 5)	Ln IPGP (Table 3, col. 4)	Ln IPGP (Table 3, col. 5)
Coefficient	1.1149	0.5794	0.1576	–0.1836
Standard Error	(0.4079)	(0.4542)	(0.2035)	(0.2269)
Standard Deviation (regressor)	0.2802	0.2802	0.5643	0.5643
Standard Deviation (regressand)	1.3449	1.3449	1.3535	1.3535
Standardized Coefficient	0.2323	0.1207	0.0657	–0.0765
Standardized Standard Error	(0.0850)	(0.0946)	(0.0848)	(0.0946)

Table 6 The Effect of Intellectual Property Protection (Ginarte-Park Index Dummy
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)	(5)
Ln IPGPD	0.476***	0.163	0.075	0.075	–0.142
	(0.170)	(0.158)	(0.164)	(0.173)	(0.193)
Ln SALES		0.304***	0.407***	0.407***	0.373***
		(0.079)	(0.092)	(0.109)	(0.182)
Ln INTFUNDS		0.056	0.072	0.072	0.065
		(0.071)	(0.075)	(0.081)	(0.079)
Ln ENROLL		0.723	1.176**	1.176*	0.540
		(0.466)	(0.557)	(0.687)	(0.706)
Ln TOI		–0.228	–0.214	–0.214	–0.267
		(0.358)	(0.362)	(0.520)	(0.532)
Ln EFI		0.033	0.032	0.032	0.083
		(0.418)	(0.438)	(0.537)	(0.551)
Constant	–4.984***	–10.302***	–12.756***	–12.756***	–9.773***
	(0.170)	(1.507)	(2.312)	(2.960)	(3.474)
Year fixed effects	No	No	Yes	Yes	Yes
HAC	No	No	No	Yes	Yes
Country fixed effects	No	No	No	No	Yes
P (year fixed effects 0)			0.020	0.047	0.068
P (all slopes 0)	0.000	0.000	0.000	0.000	0.000
$\bar{R}^2$	0.276	0.337	0.331	0.331	0.251
N	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.
*** denotes significance at the 1% level; ** denotes significance at the 5% level.

Table 7: The Effect of Intellectual Property Protection (Ginarte-Park Index Dummy 2)
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)	(5)
Ln IPGPD2	0.558***	0.223	0.132	0.132	–0.014
	(0.173)	(0.162)	(0.166)	(0.205)	(0.224)
SALES		0.292***	0.394***	0.394***	0.350**
		(0.079)	(0.094)	(0.106)	(0.177)
INTFUNDS		0.052	0.068	0.068	0.062
		(0.070)	(0.075)	(0.080)	(0.078)
ENROLL		0.715	1.108**	1.108*	0.531
		(0.466)	(0.557)	(0.642)	(0.702)
TOI		–0.218	–0.214	–0.214	–0.260
		(0.355)	(0.359)	(0.523)	(0.526)
EFI		0.053	0.034	0.034	0.077
		(0.416)	(0.435)	(0.538)	(0.552)
Constant	–4.950***	–10.219***	–10.286***	–10.286***	–9.620***
	(0.164)	(1.506)	(2.320)	(2.753)	(3.395)
Year fixed effects	No	No	Yes	Yes	Yes
HAC	No	No	No	Yes	Yes
Country fixed effects	No	No	No	No	Yes
P (year fixed effects 0)			0.023	0.058	0.073
P (all slopes 0)	0.000	0.000	0.000	0.000	0.000
$\bar{R}^2$	0.267	0.339	0.334	0.334	0.288
N	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 Protection (Components of the Ginarte-Park Index)
Dependent Variable – Ln RDPA

Regressor	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)	(5a)	(5b)
Ln ICOV	–0.177	–0.661								
	(0.590)	(0.637)								
Ln IDUR			0.613	–0.142						
			(0.827)	(0.831)						
Ln IMEM					0.509	–0.347				
					(0.608)	(0.634)				
Ln IREV							0.270	–0.369		
							(0.425)	(0.559)		
Ln IENF									–0.336	–0.594
									(0.389)	(0.444)
Ln SALES	0.421***	0.361**	0.422***	0.345*	0.394***	0.363*	0.408***	0.357**	0.421***	0.354**
	(0.113)	(0.180)	(0.108)	(0.179)	(0.118)	(0.186)	(0.111)	(0.179)	(0.107)	(0.167)
Ln INTFUNDS	0.074	0.058	0.076	0.061	0.080	0.057	0.071	0.063	0.060	0.036
	(0.082)	(0.078)	(0.085)	(0.080)	(0.083)	(0.079)	(0.082)	(0.078)	(0.082)	(0.078)
Ln ENROLL	1.190*	0.499	1.145*	0.538	1.158*	0.487	1.086*	0.532	1.255*	0.596
	(0.661)	(0.696)	(0.604)	(0.697)	(0.679)	(0.673)	(0.639)	(0.700)	(0.686)	(0.753)
Ln TOI	–0.191	–0.152	–0.272	–0.245	–0.227	–0.251	–0.239	–0.242	–0.135	–0.117
	(0.549)	(0.545)	(0.556)	(0.556)	(0.525)	(0.535)	(0.527)	(0.539)	(0.532)	(0.543)
Ln EFI	0.041	0.053	0.102	0.058	0.066	0.055	0.056	0.063	0.062	0.103
	(0.547)	(0.563)	(0.598)	(0.596)	(0.550)	(0.558)	(0.532)	(0.561)	(0.540)	(0.554)
Constant	–12.903***	–9.557***	–13.088***	–9.526***	–12.677***	–9.454***	–12.419***	–9.608***	–13.245***	–10.034***
	(2.862)	(3.382)	(2.763)	(3.561)	(2.970)	(3.282)	(2.788)	(3.393)	(2.958)	(3.600)
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)	0.052	0.057	0.055	0.083	0.083	0.140	0.068	0.072	0.038	0.032
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
$\bar{R}^2$	0.311	0.237	0.338	0.283	0.347	0.252	0.330	0.257	0.301	0.240
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 9: The Effect of Intellectual Property Protection (Ginarte-Park Index)
Dependent variable – Ln RDPAC

Regressor	(1)	(2)	(3)	(4)	(5)
Ln IPGP	0.086	–0.878*	–0.331	–0.331	–0.799
	(0.373)	(0.531)	(0.546)	(0.499)	(0.570)
Ln SALES		0.358***	0.483***	0.483***	–0.420
		(0.119)	(0.129)	(0.097)	(0.322)
Ln INTFUNDS		–0.196	–0.013	–0.013	–0.042
		(0.179)	(0.189)	(0.180)	(0.216)
Ln ENROLL		1.607*	2.064**	2.064**	–0.103
		(0.912)	(0.913)	(0.806)	(0.752)
Ln TOI		–2.173*	–2.425*	–2.425	0.338
		(1.194)	(1.205)	(1.616)	(1.736)
Ln EFI		0.591	0.230	0.230	3.957
		(1.078)	(1.061)	(1.131)	(1.549)
Constant	–6.447***	–12.653***	–14.867***	–14.867***	–9.201*
	(0.517)	(3.694)	(3.688)	(3.526)	(5.226)
Year fixed effects	No	No	Yes	Yes	Yes
HAC	No	No	No	Yes	Yes
Country fixed effects	No	No	No	No	Yes
P (year fixed effects 0)			0.013	0.077	0.121
P (all slopes 0)	0.817	0.001	0.000	0.000	0.119
$\bar{R}^2$	0.080	0.313	0.377	0.377	0.188
N	113	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 10: The Effect of Contemporaneous vs. Following Period Index of Protection (Ginarte-Park Index)
Dependent variable – Ln RDPA

Regressor	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)	(5a)	(5b)
Ln $IPGP_t$	0.725***		0.358**		0.345*		0.345*		–0.102	
	(0.122)		(0.178)		(0.185)		(0.185)		(0.224)	
Ln $IPGP_{t+1}$		0.623***		0.226		0.368**		0.368**		0.031
		(0.127)		(0.173)		(0.185)		(0.184)		(0.190)
Ln SALES			0.325***	0.350***	0.378***	0.404***	0.378***	0.404***	0.242	0.250
			(0.093)	(0.092)	(0.096)	(0.096)	(0.096)	(0.100)	(0.188)	(0.186)
Ln INTFUNDS			0.081	0.086	0.085	0.095	0.085	0.095	0.069	0.074
			(0.084)	(0.084)	(0.087)	(0.087)	(0.094)	(0.098)	(0.082)	(0.084)
Ln ENROLL			0.845	1.068*	1.216*	1.181*	1.216	1.181	0.301	0.279
			(0.601)	(0.597)	(0.634)	(0.635)	(0.789)	(0.740)	(0.908)	(0.906)
Ln TOI			–0.543	–0.517	–0.422	–0.475	–0.422	–0.475	–0.354	–0.410
			(0.399)	(0.405)	(0.401)	(0.406)	(0.566)	(0.567)	(0.563)	(0.570)
Ln EFI			–0.229	–0.238	–0.074	–0.070	–0.074	–0.070	0.062	0.076
			(0.451)	(0.456)	(0.474)	(0.474)	(0.665)	(0.684)	(0.696)	(0.670)
Constant	–5.481***	–5.490***	–10.129***	–11.246***	–12.322***	–12.352***	–12.322***	–12.352***	–7.560*	–7.540*
	(0.175)	(0.194)	(2.221)	(2.158)	(2.550)	(2.521)	(3.294)	(2.986)	(4.242)	(4.238)
Year fixed effects	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
HAC	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Country fixed effects	No	No	No	No	No	No	No	No	Yes	Yes
P (year fixed effects 0)					0.060	0.020	0.165	0.091	0.033	0.052
P (all slopes 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\overline{R}^2$	0.348	0.284	0.384	0.347	0.382	0.371	0.382	0.371	0.162	0.234
N	190	190	190	190	190	190	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 Contemporaneous vs. Following Period Index of Protection (Sims-type test)
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)	(5)
Ln $IPGP_t$	0.658***	0.335	0.186	0.186	–0.175
	(0.204)	(0.221)	(0.236)	(0.221)	(0.247)
Ln $IPGP_{t+1}$	0.081	0.032	0.245	0.245	0.125
	(0.206)	(0.213)	(0.236)	(0.213)	(0.207)
Ln SALES		0.325***	0.392***	0.392***	0.261
		(0.093)	(0.097)	(0.100)	(0.187)
Ln INTFUNDS		0.082	0.092	0.092	0.073
		(0.084)	(0.087)	(0.097)	(0.084)
Ln ENROLL		0.827	1.103*	1.103	0.241
		(0.616)	(0.644)	(0.769)	(0.889)
Ln TOI		–0.551	–0.488	–0.488	–0.396
		(0.404)	(0.406)	(0.572)	(0.577)
Ln EFI		–0.230	–0.062	–0.062	0.061
		(0.454)	(0.474)	(0.670)	(0.698)
Constant	–5.507***	–10.060***	–11.955***	–11.955***	–7.439*
	(0.191)	(2.288)	(2.579)	(3.152)	(4.176)
Year fixed effects	No	No	Yes	Yes	Yes
HAC	No	No	No	Yes	Yes
Country fixed effects	No	No	No	No	Yes
P (year fixed effects 0)			0.039	0.162	0.031
P (all slopes 0)	0.000	0.000	0.000	0.000	0.000
$\bar{R}^2$	0.345	0.381	0.383	0.383	0.173
N	190	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 12: The Effect of Intellectual Property Protection (Ginarte-Park index, lagged)
Dependent variable – Ln RDPA

Regressor	(1)	(2)	(3)	(4)	(5)
Ln $IPGP_{t-1}$	0.612***	–0.082	0.103	0.103	–0.36**
	(0.130)	(0.181)	(0.195)	(0.151)	(0.159)
Ln SALES		0.339***	0.433***	0.433***	0.320
		(0.090)	(0.099)	(0.118)	(0.245)
Ln INTFUNDS		–0.004	0.064	0.064	0.022
		(0.081)	(0.088)	(0.100)	(0.093)
Ln ENROLL		1.201*	1.512**	1.512*	1.140
		(0.620)	(0.669)	(0.830)	(0.861)
Ln TOI		0.156	–0.262	–0.262	–0.040
		(0.533)	(0.557)	(0.806)	(0.855)
Ln EFI		–0.107	0.016	0.016	–0.098
		(0.513)	(0.552)	(0.739)	(0.836)
Constant	–5.252***	–13.078***	–14.640***	–14.640***	–12.108***
	(0.189)	(2.325)	(2.747)	(3.523)	(4.026)
Year fixed effects	No	No	Yes	Yes	Yes
HAC	No	No	No	Yes	Yes
Country fixed effects	No	No	No	No	Yes
P (year fixed effects 0)			0.148	0.050	0.331
P (all slopes 0)	0.000	0.000	0.000	0.000	0.000
$\bar{R}^2$	0.313	0.290	0.323	0.323	0.169
N	190	190	190	190	190

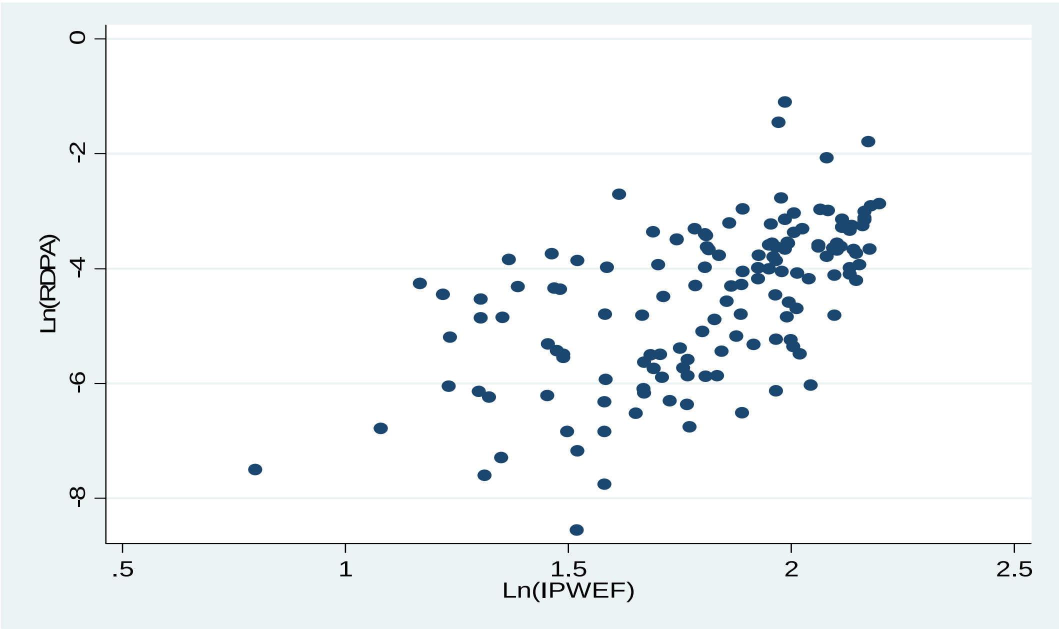
Note: Standard Errors are reported in parentheses below the regression coefficients
HAC refers to heteroscedasticity and autocorrelation consistent standard errors.
***, **, and * denote significance at the 1%, 5% and 10% levels.

Table A2.1: The Effect of Intellectual Property Protection (World Economic Forum index, lagged)
Dependent variable – Ln RDPA

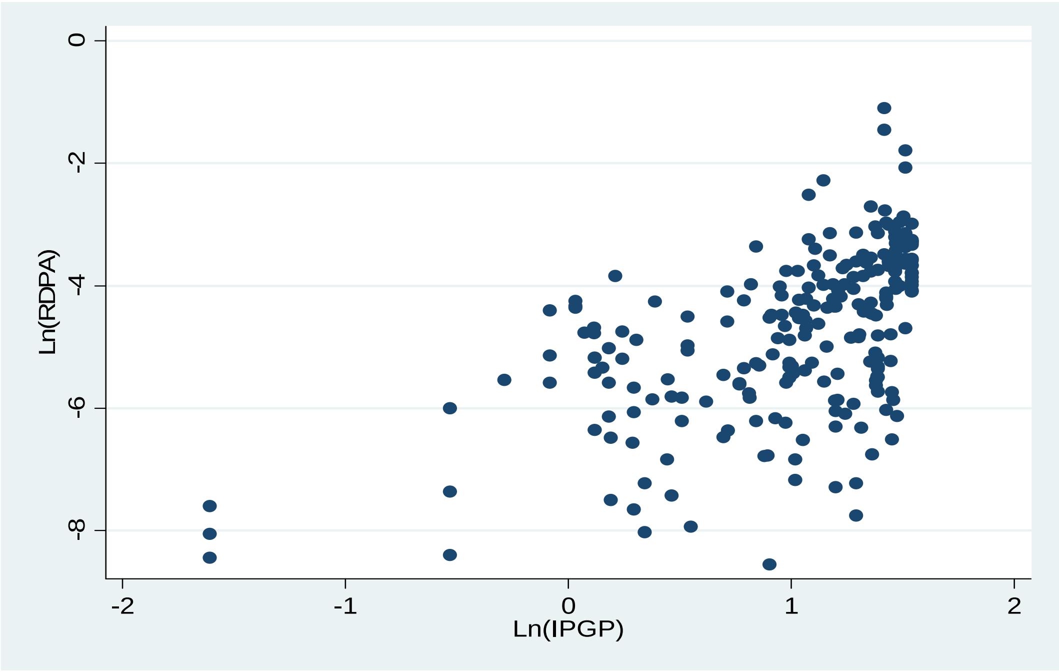
Regressor	(1)	(2)	(3)	(4)	(5)
Ln $IPWEF_{t-1}$	0.833***	–0.134	0.183	0.183	–0.256
	(0.308)	(0.469)	(0.519)	(0.505)	(0.520)
Ln SALES		0.287**	0.415***	0.415**	0.357
		(0.118)	(0.138)	(0.169)	(0.458)
Ln INTFUNDS		–0.014***	0.073	0.073	0.059
		(0.156)	(0.163)	(0.145)	(0.241)
Ln ENROLL		0.880	1.070	1.070	1.259
		(0.838)	(0.858)	(0.997)	(1.180)
Ln TOI		0.705	0.429	0.429	0.280
		(0.925)	(1.032)	(1.420)	(1.592)
Ln EFI		1.045	0.923	0.923	0.972
		(0.870)	(0.870)	(1.191)	(1.519)
Constant	–5.925***	–14.370***	–15.975***	–15.975***	–15.319**
	(0.585)	(3.430)	(3.751)	(4.394)	(6.673)
Year fixed effects	No	No	Yes	Yes	Yes
HAC	No	No	No	Yes	Yes
Country fixed effects	No	No	No	No	Yes
P (year fixed effects 0)			0.220	0.142	0.922
P (all slopes 0)	0.007	0.001	0.000	0.013	0.380
$\bar{R}^2$	0.257	0.304	0.332	0.332	0.300
N	100	100	100	100	100

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: Scatterplots of R&D Performed by Affiliates (*RDPA*) against the indices of protection



(a)



(b)

Endnotes

[1] Strictly speaking, innovation has to do with the technology in existence whereas technological change has to do with 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 behind 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). Note, however, that such reallocation 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] 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), appearing 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.

[4] 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.

[5] There's 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).

[6] 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.

[7] 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.

[8] 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?.

[9] In addition to indices *IPWEF* and *IPGP*, two 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. For details, see Appendix 1.

[10] Of course, it is quite possible that a particular location may be used to serve not just that (local) market, but other markets as well; in which case, the size of that local market may not be the determining factor. It would be possible to avoid this slippage 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.

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

[12] 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.

[13] The levels of the index of protection *IPGP2* 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.

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

[15] 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.

[16] 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.

[17] Similar conclusions follow when we re-do the exercises of section 4.1 using lagged *IPWEF* as the intellectual property protection variable. The results are reported in Appendix 2, Table A2.1.