CHAPTER 1

Does Patent Protection Help or Hinder Technology Transfer?

by

Bronwyn H. Hall[1]

Abstract

The theoretical and empirical evidence on the relationship between the strength of patent protection in a country and technology transfer of various kinds to that country is surveyed. The conclusions are that stronger patent protection encourages FDI and technology transfer to mid-level developing countries, but that there is little clear evidence that stronger patent protection encourages indigenous innovation in developing countries, except possibly in the chemicals sector. The paper concludes with suggestions for future research.

1. Introduction

The question posed by the title to this paper is in some ways an old one that has been studied by a large number of economists, going back at least to Mansfield's pioneering survey work on the question. Recently interest in the topic has been reinvigorated by the adoption of the TRIPS agreement and an increased interest in innovative activities as a driver of economic development. The justification for the present survey is that evidence on Intellectual Property Rights (IPRs) and technology transfer has been accumulating recently and it seemed

[1] University of California at Berkeley and University of Maastricht. A revised and extended version of portions of this paper was published as Hall, Bronwyn H. and Christian Helmers, The Role of Patent Protection in (Clean/Green) Technology Transfer, *Santa Clara Computer and High Technology Law Journal* 26: 487-532.

worthwhile to have another look at the topic, especially as this relationship pertains to developing and emerging economies.

In the past, study of this question has not led to clear and unambiguous conclusions. The recent introduction of the TRIPS agreement at the WTO has meant some harmonization of patent rights worldwide, largely in the direction of strengthening them in developing countries, and many economists (and others) have critiqued this step as negative rather than positive for the economic development of these countries. If a conclusion were to be drawn, the available evidence suggests that "one-size-fits-all" harmonization of patent rights and IPRs in general is not welfare-enhancing for less developed countries, and possibly not even for developed countries. This paper reviews the economic evidence on the IP-tech transfer-development relationship and then suggests some areas for further research.

If we unpack the question about the relationship between the strength of the patent system and innovation in developing countries, we find that there are at least two separate but related questions whose answers may be somewhat at odds with each other when considering IP policy. The first is whether stronger patent protection in a host country encourages technology transfer to that country. In particular, how does the presence of patent protection affect the behavior of foreign firms that may potentially invest in the country, sell technology to firms in the country, or form joint ventures with domestic firms? The second question is whether stronger patent protection encourages technology development in the country itself. That is, how does it affect the behavior of domestic firms? The first question has been easier to answer but the second is probably more important for the development of the country in question.

With respect to the first question, *a priori* it seems clear that stronger IP protection in the host country should encourage (or at least not discourage) the transfer of technology by foreign firms to their subsidiaries and possibly to domestic firms, either via partnership or simple sale or licensing. Note that this argument presumes that the intellectual property rights are enforceable, which is not an innocuous assumption. Also, note that such transfer may or may not help the local development of innovation skills and human capital. With respect to the

second question, it also seems clear that stronger IP protection could encourage the innovative activities of domestic firms, but that such protection could also discourage learning via imitation and therefore inhibit technological catch-up. Thus the impact of IP systems on technological development is ambiguous and requires further investigation.

Of course, IP protection comes in several different forms: patents, copyright, trademarks, trade secrecy, and some specialized forms such as semiconductor mask protection, and these might be expected to have different effects. The primary focus of the present paper will be patents, as these are arguably the most important form of protection for technological innovations. However, the other forms of IP protection can be important for securing returns to innovation and diffusion, and are often used in tandem with patents. See Abud et al. 2013 for a look at the Chilean case. Where appropriate, notice will be taken of the impact of other types of IP.

I also note that there are already a number of useful surveys of this general topic available in the literature: see Branstetter (2004), Maskus (2004), and ICTSD and UNCTAD (2003). However, new work has appeared since these surveys and it is useful to have another look at the problem, with a view towards identifying unanswered questions for future research.

1.1. Technology transfer

International technology transfer typically takes place via trade, foreign direct investment, joint ventures with local partners, or simple technology licensing, although in the latter case, some tacit knowledge probably also needs to be transferred. In all of these cases, foreign firms run the risk that imitation by local firms may erode some of their profits from these activities, so the presence of enforceable IPRs should encourage all these activities. In fact, Edith Penrose goes as far as to argue that for developing countries "the only economic advantages to be gained from granting foreign patents lies in the possibility that in one way or another such grants will induce the introduction of foreign technology and capital" (Penrose, 1973: 770).

Obviously, in the cases of more advanced technology, the imitation risk is highest when the host country has the capacity to adopt and develop such technology, which implies that the risk is generally greater in middle income countries than in low income countries. This risk is further increased, if technologies require local adaptation in order to fit local needs and regulatory requirements and standards. At the same time, if IPR protection is strong, foreign firms may prefer to license technologies instead of choosing to be a local presence, which could decrease the amount of technology transferred. This decision may also be influenced by the ability of foreign firms to enforce license contracts. However, it is also conceivable that stronger IPRs increase the incentives for firms to exploit IPRs themselves instead of licensing out. It is likely that these relationships differ by industry and type of activity, i.e., manufacturing or distribution.

How true is this in practice? That is, what is the evidence that local IP protections matter when a firm considers transferring its technology to another country? In this section of the paper I review the evidence on three channels of technology transfer that are affected by the recipient country IP system: trade, foreign direct investment (FDI), and technology licensing.

1.2. Technology transfer through trade

Technology transfer via trade can occur in at least two ways. First, imported products that are more advanced than locally produced goods may provide an opportunity for reverse engineering and imitation. Second, importing various kinds of capital equipment or even business services may help local firms undertake process innovation and technical change in production. The former strategy is obviously discouraged by a strong domestic IP system, whereas the latter may be encouraged. Maskus and Penubarti (1995) provide some empirical evidence for a positive correlation between the strength of patent enforcement and the level of manufacturing imports originating in OECD countries using a cross-section of 28 manufacturing sectors across 47 developed and developing countries, finding that the level of

manufacturing imports is positively correlated with the strength of patent enforcement in the importing countries. The authors also account for the potential endogeneity of the patent enforcement measure by using an instrumental variable approach, although finding valid instruments in this context is a difficult task.

In a similar analysis, Smith (1999) looks at the correlation between U.S. exports and IPR protection in developing countries by estimating a gravity equation. Smith distinguishes in her analysis between countries with different degrees in the prevailing threat of imitation - that is the importing country's ability to imitate. She finds a positive correlation between U.S. exports and the importing country's strength of IP protection only for countries with high risk of imitation. These findings have been confirmed more recently by Awokuse and Yin (2010) who look specifically at the relationship between imports and IPR protection in China using panel data for 1991-2004. In addition to the patent rights index used in the work discussed above, Awokuse and Yin use patent applications by foreign applicants as a measure for the strength of IPRs in China and find that imports by China increase with stronger patent rights protection and that this effect is strongest for high-tech industries.

These results suggest that trade serves indeed as a channel for international technology transfer and also that developed countries are wary of transferring knowledge in embodied form to countries with strong imitative capacity and weak IPR enforcement.

1.3. Technology transfer through FDI

The first author to look at Foreign Direct Investment (FDI) as a channel for technology transfer empirically was Edwin Mansfield, in a 1991 survey of approximately 100 U.S. multinational firms (Mansfield 1994) and their experiences with 16 countries drawn from all over the world. Broadly speaking, his findings were that most U.S. multinationals evaluate the strength of IP protections in the host country before making investments abroad; the effects varied by industrial structure and were especially strong in the case of R&D facilities and in the

chemical/pharmaceutical sector, not surprisingly. In assessing the evidence, Mansfield was careful to point out the three factors that led to the firm's perception of IP strength: 1) does the law protect their technology?; 2) is there adequate legal infrastructure in the country to enable enforcement?; and 3) do the relevant government agencies treat foreign entities the same as domestic in this area? All three were to be taken into account in answering the survey.

In Lee and Mansfield (1996), these data were augmented with data on actual foreign direct investment by U.S. firms in the countries during four years from 1990 to 1993 and simple regressions were used to show that FDI does indeed vary with the perceived strength of IP protection. Mansfield (2000) performed a similar exercise using data on firms in Japan and Germany as well as the U.S. and found even larger effects. Given the relatively small sample size in the U.S. study (effectively 16 countries, although there are 48 observations due to the time dimension), this result is reassuring.

Heald (2003) critiques the strong conclusions that have been drawn from this study by others as making too little distinction among the different kinds of IP rights that might be used. In particular, although the study is often cited to show that patents are important for technology transfer, Heald argues that trade secrecy may have been equally important in the eyes of the survey participants. The original Mansfield article cites a number of comments by survey participants that suggest that disclosure of proprietary information is what they fear most. As Heald points out, this information is already disclosed if the invention has been patented elsewhere, so the presence or absence of local patent protection may be irrelevant. Turner and Heald (2004) propose a new survey that distinguishes among the various kinds of IP rights, but unfortunately their survey achieved response rates that were too low for valid analysis (Turner, 2010, private communication).

In a major study of U.S. multinational firm behavior in response to the strengthening of patent systems in 16 middle income countries during the 1990s, Branstetter et al. (2006) found that royalty payments received for technology, R&D spending by the firm's local affiliates, and foreign origin patent applications at the USPTO all increased following these changes,

especially if the firm in question was already a heavy patent user, and therefore presumably dependent on patents to secure returns to innovation.

Javorcik (2002) studies the relationship between a country's probability of receiving FDI and its level of IP protection for 24 Eastern bloc transition economies for the period 1989-1994. Javorcik uses the Ginarte and Park (1997) IPR index which measures statutory IP enforcement and complements it with information on actual IPR enforcement. Her findings suggest that the level of IPR protection is positively correlated with the propensity to receive FDI in high-tech sectors (drugs, cosmetics and health care products; chemicals; machinery and equipment; electrical equipment). In countries with weak IPR protection, FDI focuses on distribution activities instead of the establishment of local production facilities.

In a similar analysis, Park and Lippoldt (2008) analyze the relationship between the strength of IPRs and technology transfer measured as inward FDI stocks and imports of goods and services for a sample of 120 countries over the period 1990-2005. The authors construct separate Ginarte-Park type indices for patents, trademarks and copyrights to measure the strength of IP protection in a given country. The authors find the patent rights index to be positively correlated with all three measures of technology transfer. This positive relationship is weaker for trademarks and copyrights. With regard to technology transfer to developing countries, Park and Lippoldt find a positive association between stronger patent rights and high-tech imports such as pharmaceuticals, chemicals and office and telecom equipment. Their data also suggest a positive correlation between the number of patents held by non-residents in developing countries and the amount of FDI and imports of goods and services received. The authors argue that this shows that foreigners transfer new technologies in the presence of strong IP rights. Clearly it also means that they take advantage of the local IP system.

The literature reviewed above treats FDI as a single homogenous channel of technology transfer. Ito and Wakasugi (2007) distinguish between different types of FDI. They estimate the probability that affiliates of Japanese manufacturing multinational companies engage in R&D in

a sample of developed and developing host countries. They distinguish between affiliates conducting R&D (a) at the manufacturing plant site without the establishment of a research laboratory and (b) at both the plant site and a research laboratory. They interpret (a) as a sign that an affiliate conducts only R&D to adapt existing technologies to the host market, whereas (b) is regarded as "knowledge sourcing R&D" which involves the generation of new knowledge and technologies. The authors find a positive correlation between the strength of a host country's IPR enforcement regime measured as a patent right index and the probability of a Japanese affiliate conducting knowledge sourcing R&D. Since this type of R&D can be expected to have the largest technology transfer component, the finding also suggests that stronger IPRs are correlated with increased technology transfer through the channel of FDI; it may also suggest that the technology transfer is flowing both ways.

While this literature suggests that IPR enforcement is important, there may be a large number of other factors that also determine multinational companies' decisions to engage in FDI. Fosfuri (2004), for example, compares the importance of IPR protection and country risk in determining international investment activities of large multinational chemical processing firms in 75 countries during the period 1981-1996. Fosfuri has information on three modes of international activity of the firms in the sample, i.e., wholly owned operations, joint ventures and licensing. He finds firms to be sensitive to the measure of country risk, measured by the Institutional Investor Credit ratings, with all three forms of a foreign firm's engagement being negatively correlated with country risk in the host economy. In contrast, the level of IPR protection is not correlated in a statistically significant way with any form of foreign firms' engagement in the host economy. This may be partly explained by the fact that the measure of IPR protection is based on statutory protection and might differ from actual enforcement. It still suggests that IPRs are only part of a more complex set of determinants of FDI, as was found by Thursby and Thursby (2006) in their survey of multinational firms.

Does this fact also help to explain why we often see foreign R&D investments in countries with weak IPR enforcement? Zhao (2006) looks into this seeming conundrum analyzing data on

1,567 holding companies headquartered in the U.S. and active in 48 developing and developed countries. Zhao shows that patents filed at the USPTO by these companies receive more forward citations within a holding company if at least half of the inventors of the patent are located in a country with weak IPR protection. Zhao interprets this self-citation pattern within a holding company as evidence for disproportionately more knowledge exchange internal to the holding company in the case of research undertaken in countries with weak patent protection. Hence, the results suggest that multinational companies conduct R&D in countries with weak IPR protection when the resulting innovation is integrated into larger global R&D projects of the holding company. In this case, the value of an innovation emerges only when it is integrated and complemented with knowledge and resources held by the company abroad. Therefore, the potential loss due to imperfect appropriability of knowledge in these countries is counterbalanced by the cost advantage due to low cost researchers in developing countries which explains companies' willingness to engage in FDI in developing countries with weak IPR protection.

Chen (2008) suggests that the availability of a large pool of high-skilled, specialized scientists is even more important than low wages. He investigates the motives of multinational companies to establish R&D labs in Beijing. The results of his qualitative survey of 18 R&D labs established by multinational companies in Beijing also reveals a range of other relevant location-specific factors such as the possibility to conduct joint research projects with local research institutions and competitive pressures on local markets to generate innovative products. Chen's results are also consistent with Thursby and Thursby's survey, where the most important factors in locating an R&D lab in a foreign country are the expected growth of the country's economy and the availability of qualified R&D personnel, albeit closely followed by the strength of IP protection. For more on the internationalization of R&D and its determinants, see Hall (2011).

In summary, the literature indicates a positive correlation between FDI and the level of IPR enforcement. Considering the extensive evidence on FDI serving as a channel for technology

transfer, this implies a positive relation between IPR enforcement and technology transfer through the channel of FDI. However, the literature also points to other important factors in attracting FDI, such as country risk and the availability of low-cost high-skilled labor.

1.4. Technology transfer through licensing

Arora and Ceccagnoli (2006) use data from the 1994 Carnegie Mellon Survey on U.S. manufacturing firms conducting R&D to investigate the relationship between firms' licensing behavior and the strength of patent protection. The authors find that the effect of stronger patent protection on licensing depends on whether the firm owns specialized complementary assets. If they do not, stronger patent protection increases their propensity to license their technology. If they have such assets, stronger patent protection leads them to patent more but not necessarily to license more. Hence, the positive association between the strength of patent protection and licensing found by the authors comes from firms' increased patenting activity rather than a direct increase in firms' licensing activities.

Smith (2001) uses a sample of U.S. firms to analyze how the strength of patent regimes abroad influences the way in which these firms service foreign markets. She finds a stronger positive association between licenses by U.S. firms in countries with stronger IPR enforcement than for exports and sales by affiliates. Smith interprets her findings as evidence that strong IPRs give incentives to U.S. firms to transfer knowledge to foreign companies through licensing. Yang and Maskus (2009) support Smith's findings in a theoretical model. Yang and Maskus show that stronger IPRs give incentives to industrialized country firms to license technology to firms in developing countries. If these developing country firms have sufficient absorptive capacity, licensing may lead them to increase exports and therefore enhance welfare in the developing country.

Summing up, the main conclusions from the empirical evidence on IP and technology transfer are the following. First, the strength of IP protection does seem to facilitate technology

transfer to middle income countries that already have innovative capacity or are capable of imitation. Technology licensing, imports and foreign direct investment in these countries respond to stronger IP regimes. The existing evidence also suggests that absorptive capacity is important as it facilitates technology transfer through licensing, which is the channel involving the largest degree of disembodied technology transfer external to the multinational company. These conclusions seem consistent with the idea that a certain level of absorptive capacity is necessary to make use of and learn from imported technology, but that if a country has the capacity to do so, they are more likely to receive the technology if the foreign firm from which it comes feels that its ownership rights will be protected. If the absorptive capacity is present but IP protection is weak, foreign firms will tend to establish distribution rather than manufacturing subsidiaries.

In spite of the evidence that IP protection does seem to encourage technology transfer in some cases, it is important to remember that firms typically do not rank IPRs very highly as an influence on the technology transfer decision, except in the cases of R&D facilities and very advanced technologies. So individual situations will require their own evaluations.

Finally, many of the studies surveyed here rely mostly on indexes of IP strength that rest on the law as written rather than as enforced. In many developing countries this distinction may matter, and one reason for weak or inconclusive results may be that the measure of IP strength is inadequate.

2. Technological development

The results on IP and technology transfer seem sensible and consistent with *a priori* intuition. However, as suggested in the introduction, the more important question for policy is the question of the impact of strengthened IPRs on innovation and development within a developing country. Does stronger patent protection help to enable and increase that country's own innovative capacity? This question has been approached by economists in three very

different ways: using theoretical analysis, looking at the relationship between IP and innovation across countries, and using individual case studies of changes in patent law.

2.1. Theory

Grossman and Lai (2004) look at the choice of levels of IP protection among groups of countries that are subject to knowledge spillovers. They find that, in general, non-cooperative equilibria among these countries result in stronger IP protection in developed countries than in the less developed countries. Angeles (2005) uses a simple North/South model with IPRs in the North and finds that the welfare effects of adding IP protection in the South depends on the relative income levels in the North and South; the larger the gap, the less desirable for total social welfare is IP protection in the South.

Scotchmer (2004) considers a case where each country can choose to have innovation provided either by IP protection for innovators or by public sponsorship of innovation. In this case, national treatment of innovators and harmonization across countries both lead to too much IP protection and too little public sponsorship in all of the countries relative to the social welfare optimum. Small countries will favor more extensive harmonization of IP rights than large countries (c.p.), because the consumer surplus they generate is in other countries for the most part. In addition, more innovative countries will favor more extensive IP rights (c.p.).

The conclusions from the theoretical literature are fairly clear: in the absence of any kind of coordinated action, more developed countries will have stronger IP protection than less developed. In addition, harmonization generally leads to levels of IP protection that are higher than the social optimum, at least in the less developed countries. As these models predict, the tendency is for IP protection strength to harmonize upward rather than downward.

2.2. Empirical cross country evidence

Few well-designed natural experiments exist for the study of IP protection and innovative activity, and most are not specifically addressed to the development question, being instead simply directed towards the general IP-innovation relationship. There are however a fairly large number of simple cross country studies, both contemporary and using historical data. These studies vary in quality and persuasiveness due to the presence of simultaneity between the development of an economy and the development of an IP system, although some of the authors have attempted to find instrumental variables to mitigate this problem.

There are two large scale historical studies, both of which take advantage of the variability of patent systems around the world in the 19th century and both of which are creative in finding an indicator of innovative activity other than domestic patenting. This is necessary because we know that such patenting usually will increase when patents become more desirable because subject matter is broadened or they are stronger, but this does not necessarily mean that innovation has increased, which is the relevant question. Lerner (2002) compares patenting activity in the UK across countries with various strengths of the patent system and finds that patenting by domestic entities in these countries at the UK patent office actually declines when their patent system is strengthened, whereas patenting by foreign entities in the countries increases. Moser (2005) uses Crystal Palace exhibits as a proxy measure of innovative activity and finds that countries with stronger patent systems do not produce more innovation, but that innovation in countries with weak or no patent systems tends to favor technologies that can be protected by trade secrets. So both of these investigations fail to find strong overall effects of patenting on innovation during the 19th and early 20th centuries, although Moser does find an influence on the direction of innovative activity.

In the first study of this kind using contemporary data, Park and Ginarte (1997) uses aggregate data for 60 countries during from 1960-1990 and an index of the strength of IP rights (subject matter coverage, term length, etc.) which these authors developed. Using a simultaneous equations model of economic growth, investment, schooling, and R&D investment, they found that the strength of IP rights was positively associated with investment

and R&D investment in countries with above median income but not for the less-developed countries. IP rights had no independent effect on growth above and beyond that contributed by investment and R&D, a not unexpected result. However, Ginarte and Park (1997) also shows that the strength of IP rights in high income countries (but not in low income countries) can be predicted by prior R&D intensity, which raises some questions about the simultaneity of IP protection and a country's orientation towards R&D and innovation. That is, it is possible that the demand for IP protection increases when a large share of the industrial base is engaged in innovative activities.

The index developed by Ginarte and Park has been updated in Park (2008), and has been widely used in a number of subsequent studies. The index itself is composed of 5 pieces related to subject matter coverage, duration of coverage, international treaty membership, enforcement provisions, and measures that cause the loss of protection. The index does not include any measure of the adequacy of the enforcement measures, although the Ginarte-Park paper itself contains a useful discussion of the empirical evidence on corruption and lack of effective enforcement. In a more recent study, Allred and Park (2007) use an updated patent rights index to look at the relation between IPR protection and patenting at the country level for a sample of 100 countries during 1965-2000. Allred and Park find a non-linear relationship between the IPR index and domestic patenting – for low values of the index a strengthening of patent rights is negatively correlated with domestic patenting whereas the relationship is positive beyond a threshold level of the index. Also using the Ginarte-Park patent rights index, Park and Lippoldt (2008) find for their analysis a positive correlation between patent strength and the number of patent applications by developing countries as well as R&D intensity, i.e., R&D expenditure as a percentage of GDP. The authors interpret this as evidence for stronger IP rights to be beneficial for the domestic development of technology in developing countries. However, the econometric methodology in this study as in the earlier studies does not incorporate dynamics and it is not clear whether there is a degree of reverse causality in the findings.

The study by Kanwar and Evenson (2003) looks at the variation across country in R&D spending as a function of the Ginarte-Park index over the 1981-1995 period and finds similar results, with stronger IP protection related to higher R&D intensity. Although well done in many respects, as in the studies described previously this study makes no attempt to explore the potential endogeneity of the relationship nor does it control completely for the level of development of the countries, which arguably drives both R&D and the development of IP institutions.

Lederman and Maloney (2003) perform a similar exercise for 73 countries during the 1975-2000 period, but allow for endogeneity of the relationship. They use a system GMM estimator with lagged values of the right hand side variables as instruments and find that stronger IP protection is significantly related to R&D intensity. The coefficient is approximately 0.2-0.4, with a coefficient for lagged R&D intensity of 0.68-0.87. This result implies that the long run response of R&D intensity to a one unit move in the Ginarte-Park index is about 1.3 per cent. This corresponds to the difference between Argentina and Finland in the early 1990s, or between the leaders and laggards in the European Union, for example.

Chen and Puttitanum (2005) look at 64 developing countries, also during the 1975-2000 period, using a two equation model where the strength of IPRs is a function of the development level, trade openness, economic freedom, and membership in the WTO) and innovation (proxied by patenting at the US Patent Office) is a function of IPR strength, development level (GDP per capita), economic freedom, and population. The use of the two equation model is an attempt to control for the potential endogeneity of IPR strength with respect to the level of development (and hence the level of innovation). The instruments for IPR strength are confined to trade openness and WTO membership, which makes identification rather weak. Nevertheless, they show that IPRs have a positive effect on innovation and also that there is U-shaped relationship between IP strength and the level of development, with IP strength first decreasing and then increasing. Because they included a quadratic for GDP per capita in the IPR

equation but not in the innovation equation they cannot say whether the innovation-IP relationship is also U-shaped.

Qian (2007) does a thorough and careful analysis of the effects of introducing pharmaceutical product patents in 85 countries 1978-99 using matched samples and fixed country effect estimation to attempt to control for simultaneity and left-out variables. She finds that national patent protection does not stimulate domestic innovation activities, except at higher development levels, and that above a certain level of patent protection, innovation activities are actually reduced.

McCalman (2001) develops a growth model of bilateral tech transfer and tries to quantify the welfare effects of patent harmonization due to the TRIPS agreement. He finds large transfers to the US from developing countries, and also from Canada, the UK, and Japan.

A few conclusions have emerged from this body of work. First, introducing or strengthening a patent system (lengthening the patent term, broadening subject matter coverage or available scope, improving enforcement) unambiguously results in an increase in patenting and also in the use of patents as a tool of firm strategy (Lerner, 2002; Hall and Ziedonis, 2001). Second, it is much less clear that these changes result in an increase in innovative activity (Lerner 2002), although they may redirect such activity toward things that are patentable and away from those than can be kept secret within the firm (Moser, 2005).

A third finding from the empirical literature is that if there is an increase in innovation due to patents, it is likely to be centered in the pharmaceutical, biotechnology, and medical instrument areas, and possibly specialty chemicals. This conclusion relies mostly on survey evidence from a number of countries which shows rather conclusively that patents are not among the important means to appropriate returns to innovation, except perhaps in such industries (Mansfield, 1986; Levin *et al.,* 1987; Cohen *et al.,* 2001; Arora *et al.*, 2001).

Fourth, the relationship between the strength of a domestic patent system and domestic innovation activity may be U-shaped, with domestic innovation falling at first as patent rights

are strengthened, and then rising again for developed economies with high levels of the patent rights index.

Fifth and finally, the existence and strength of the patent system affects the organization of industry, by allowing trade in knowledge, which facilitates the vertical disintegration of knowledge-based industries and the entry of new firms that possess only intangible assets (Hall and Ziedonis 2001; Arora et al 2008; Arora and Merges 2004). The argument is that, by creating a strong property right for the intangible asset, the patent system enables activities that formerly had to be kept within the firm because of secrecy and contracting problems to move out into separate entities. Although limited, research in this area supports this conclusion in the chemical and semiconductor industries. Note that the evidence cited in the previous section on the shift from FDI to technology licensing that accompanies stronger IP rights is consistent with this interpretation.

2.3. Case studies

The case study evidence on IPRs, innovation, and development is somewhat mixed. For example, Western Europe, and in particular the UK and Germany, had patent protection during most of the industrial revolution and there were some episodes where such protection appeared to slow rather than hasten technological change (Kanefsky 1978, as cited by Nuvolari 2001). Episodes of invention and innovation without patents also existed. For examples, see Foray and Hilaire-Perez (2001) on the Lyons silk weaving cooperative, Allen (1983) on the iron industry of Cleveland (UK) over the period 1850-1875, and Nuvolari (2001) on the cooperative incremental development of Cornish pumping equipment (a policy that was a response to the mine owners' experience with aggressive patent enforcement by Watt). Also note that the 19th century German chemical industry developed strongly during a period when patents were available on processes but not on products (Murmann 2003).

Allen (2006) also provides evidence suggesting that the invention and fast diffusion of machines during the industrial revolution were the result of a combination of relatively high wages and cheap energy in Britain. This created incentives to substitute energy for labor through inventions biased towards saving labor. Allen (2006) suggests that while patents may have played a role in providing incentives to inventors, the main driver of the inventions during the industrial revolution in Britain were relative factor prices rather than changes in the IP system. In fact, Allen (2006) points out that the enactment of the English patent law in 1624 before the onset of the industrial revolution appears to have had little impact on innovation in the 17th century.

Several authors have pointed to the fact that a number of successful cases of technological development appear to have taken place in the absence of strong patent protection until a certain level of development had been reached. The United States did not have national treatment of foreign patent applicants until the signing of the Paris convention in 1883, and domestic inventors were therefore free to copy inventions from the UK among others during most of the 19th century. This clearly encouraged local technology development and learning by imitation. Taiwan has followed a similar pattern, with little use of IP protection, especially internationally, until innovators in the country had developed a successful imitation strategy. Taiwanese inventors only began patenting at the USPTO in 1975 and then significantly increased their patenting in 1985.

As Kim (2002) says in summarizing his review of Korean technological and development,

> "….strong IPR protection will hinder rather than facilitate technology transfer and indigenous learning activities in the early stage of industrialization when learning takes place through reverse engineering and duplicative imitation of mature foreign products." It is "only after countries have accumulated sufficient indigenous capabilities with extensive science and technology infrastructure to

undertake creative imitation in the later stage that IPR protection becomes an important element in technology transfer and industrial activities."[2]

It is noteworthy that Korea joined the Paris convention only in 1981, greatly strengthened its patent and copyright laws in 1986 and that Korean inventor patenting in the United States only jumps up significantly in 1988 (Kumar 2003).

In Japan, the story is not as clear. Japan has had a patent system since the 19th century. After defeat in World War II, a patent system of one claim per patent that allowed for utility models, pre-grant opposition, and early disclosure, clearly designed for incremental/adaptive invention, was in place. In addition, MITI took an active role in negotiating technology transfer licensing agreements from foreign firms and during the same period incoming FDI faced difficulties (Maskus 2004). After the country had reached a high level of development, during the late 1980s and 1990s, many features of the Japanese patent system were modified to bring it more in line with those in the United States and Western Europe (Sakakibara and Branstetter, 2001; Nagaoka, 2006).

La Croix and Kawaura (1996) point out that the introduction of pharmaceutical product patents in 1975 in Japan did increase R&D in that sector. Sakakibara and Branstetter (2001) show that the strengthening of the Japanese patent system in 1988-93 did not result in increased R&D spending by Japanese firms, and Branstetter and Nakamura (2003) report that the further reforms in the 1990s did not increase innovative performance (measured as the productivity of R&D) either.

Kumar (2003) provides a useful overview of the historical relationship between IPRs, technology, and economic development in the East Asian countries and reaches much the same conclusions as Kim: "Japan, Korea, and Taiwan have absorbed substantial amount of technological learning under weak IPR protection regimes during the early phases."

---

[2] Kim (2002), p. 6.

Ryan (2010) reaches a different conclusion for his case studies in the bio-medical sector in Brazil. Brazil represents an interesting setting to study the effect of the presence of patents on technology development as it introduced product patents on pharmaceuticals only in 1996. Ryan concludes from the study of five innovation projects in the bio-medical industry that the introduction of pharmaceutical product patents has led domestic companies to invest in the development of new drugs and thus promoted domestic innovation. However, Ryan shows that cooperation with public sector research institutions was crucial in allowing private firms to innovate. He also finds that existing experience with manufacturing generics was very helpful for the firms when the patent regime changed to one where innovative new products were favored.

Finally, Léger (2005) investigates the role of IPRs in the maize breeding industry in Mexico. IPRs relevant to this industry include patents, plant breeders' rights and trademarks. Through interviews with 25 breeders representing the population in the industry, Léger finds an extremely low use of IPRs in the industry. Her qualitative evidence gathered through interviews with breeders suggests that the low use of IPRs is due to a lack of information on the IP system among local breeders, high perceived costs associated with obtaining IPRs as well as difficulties in enforcing the rights. As a result, local breeders do not perceive IPRs to increase incentives for R&D. In contrast, IPRs were found to be more important to multinational companies and are thought to provide incentives to foreign breeders to adapt technologies to Mexican needs.

Although the historical record suggests that IP systems have not been that important in economic development, the TRIPS agreement has changed things to some extent (although there are various opt-out possibilities in the agreement of course). Because we do not really have cases where the presence of strong IP has inhibited innovation and development, we don't know whether the fact that TRIPS seems to have foreclosed the imitation channel to some extent is a real problem or not. It has to be said that IPRs or the lack of IPRs are only one of the factors affecting development, and are probably a rather unimportant factor at that. It would be useful

to have more research of the type pioneered by Lanjouw (1997) that looks directly at the impact of patents on innovation in particular developing countries.

3. Conclusions

The results of the research surveyed here can be summarized as follows: first, stronger patents encourage patenting in general, and they encourage technology transfer of all kinds to mid-level developing countries (and to developed countries). However they have little effect on technology transfer to the lowest income countries.

It is difficult to find clear evidence of positive impacts of stronger patents on innovation, except in chemical-related sectors. Many other factors matter, so the experiments are often not clear, we don't observe enough variation in patent systems, and it takes time for firms to adjust. It is also rare to have an independent measure of innovation (other than patents) so some ingenuity is required. Historically, IP systems have developed in parallel with the innovative part of the economy, so there are feedback effects from growth to the strength of IP protection. Attempts to solve the causality (chicken-egg) problem using instrumental variables are not completely convincing, due to the serial correlation and slow rates of adaptation in the relevant variables (IP, growth, and R&D intensities).

These conclusions seem consistent with the idea that a certain level of absorptive capacity is necessary to make use of and learn from imported technology, but that if a country has the capacity to do so, they are more likely to receive the technology if the foreign firm from which it comes feels that its ownership rights will be protected. However, it should be remembered that although IP protection is clearly considered a favorable factor for foreign investment and technology transfer, factors such as the size of the recipient economy, its expected growth, and the availability of qualified personnel can trump IP in a multinational's decision to invest in R&D in a foreign country.

Much but not all of the work on which these conclusions are based has focused on patent protection rather than IPRs in general. However, where researchers have looked at other means of protection (trademarks and copyrights), they have found them to be much less important for technology transfer. Trade secret protection has been less studied, but the original Mansfield studies of US technology transfer suggested that this form of protection might be very important. That is, what firms feared most when investing in foreign countries was the leakage of proprietary information that was not protected by patents. Of course, this concern points also to the rule of law and its enforcement as important for the technology transfer decision. Thus it would be useful to have more research that looks at alternative forms of IP protection, especially in the nonmanufacturing sectors where they may be more important.

Another topic that has probably not received the attention it deserves is the relationship between the strength of IP rights in developing countries and new market entry. Because under TRIPS the prospects for entry via imitation are lessened, it would be helpful to have a better understanding of whether IP forms a barrier or a stepping stone to entry from the perspective of a developing country firm, to augment the view from 35,000 feet offered by the cross country regressions.

A third question worth investigating further is whether simply encouraging FDI in a country leads to significant migration of technological assets. For example, the available evidence on this topic from Latin America is fairly mixed and doesn't find very strong impacts (Alvarez 2001; Alvarez and Robertson 2004; Ciarli and Giuliani 2005; Vallejo-Carlos 2005). It appears that such FDI needs to be accompanied by measures that encourage technology transfer along with the FDI. In this regard, the FDI policies of the East Asian tigers discussed by Lall (1996, 2000) are instructive. Although Korea, Taiwan, and Singapore pursued quite different policies with respect to the level of FDI they encouraged, all these countries tended to target particular technologies and to insist on the transfer of technology to domestic firms as a condition of entry. The more general broader question is whether IP systems affect knowledge diffusion within the country. In general, the publication of patents is supposed to improve the

diffusion of knowledge about invention, but whether it does or not is a bit of an open question. At the present time, the barriers are likely to be 1) slow or inconvenient or expensive internet access to international patent office websites; 2) language barriers; and 3) lags in information availability due to patent office workloads.

Turning to the policy implications of the foregoing, Maskus (2004) offers some useful general policy suggestions both for source and for destination countries that might encourage technology transfer. For developing countries facing the problem of adapting their technological strategies to the TRIPS environment, he suggests some ways in which patent fees might be structured to encourage local firm patenting and limit the term during which large foreign firms would command substantial market power. These include lower fees for small entities and rapidly rising renewal fees to encourage placing technology in the public domain, while still allowing a period of exclusivity. Evidence from van Pottelsberghe and Rassenfosse (2007) clearly demonstrates that fees matter for the decision to keep a patent in force, which argues that such a policy is likely to have an impact.

In thinking about the results of this literature and the adoptions of TRIPS in developing countries, an important question arises - Is the marginal scientist or engineer in a developing country better employed examining patents or doing R&D? That is, does the benefit of having a patent-issuing authority exceed the cost of taking resources away from the innovative sector of the economy, especially in countries where scientists and engineers are a scarce resource? It is not clear that the answer to this question is yes. See Aranha (2002), at that time the head of INPI in Brazil, on the subject of the cost of patenting for small offices and small entities. Should international development agencies be exploring the idea of providing a general patent service to such countries? The Patent Cooperation Treaty (PCT) and the recognition of search reports from the major offices already go some of the way in this direction, but should we be doing more?

References

Abud, M. J., C. Fink, B. H. Hall, and C. Helmers (2013). *The Use of Intellectual Property in Chile*. Geneva, Switzerland: INAPI and WIPO, report draft.

Allen, R. C. (2009). *The British Industrial Revolution in Global Perspective*. Cambridge, UK: Cambridge University Press.

Allen, R. C. (1983). Collective Invention. *Journal of Economic Behavior and Organization* 4 (1), 1-24.

Allred, B. and W. Park (2007). Patent rights and innovative activity: evidence from national and firm-level data. *Journal of International Business Studies* 38, 878-900.

Alvarez, R. (2001). External Sources of Technological Innovation in Chilean Manufacturing Industry, *Estudios de Economía* 28 (1): 53-68.

Alvarez, R. and R. Robertson (2004). Exposure to foreign markets and plant-level innovation: evidence from Chile and Mexico. *Journal of International Trade & Economic Development* 13(1), 57-87.

Angeles, L. (2005). Should Developing Countries Strengthen their Intellectual Property Rights? *BE Journal of Macroeconomics* 5 (1), article 23. Available at http://www.bepress.com/bejm/topics/vol5/iss1/art23/

Aranha, J. G. (2002). The Challenge for the Medium-Sized Office. Presentation to the WIPO Conference on the International Patent System. Geneva, Switzerland.

Arora, A., and M. Ceccagnoli (2008). Patent Protection, Complementary Assets, and Firms' Incentives for Technology Licensing. *Management Science* 52 (2), 293-308.

Arora, A., Ceccagnoli, M. and Cohen, W. (2003). R&D and the patent premium. *International Journal of Industrial Organization* 26 (5), 1153-1179.

Arora, A., Fosfuri, A. and Gambardella, A. (2001). *Markets for Technology: The Economics of Innovation and Corporate Strategy*. Cambridge, MA: MIT Press.

Arora, A., and R. P. Merges (2004). Specialized Supply Firms, Property Rights, and Firm Boundaries. *Industrial and Corporate Change* 13, 451-475.

Awokuse, T.O. and H. Yin (2010). Does Stronger Intellectual Property Rights Protection Induce More Bilateral Trade? Evidence from China's Imports. *World Development* 38, 1094-1104.

Branstetter, L. G. (2004). Do Stronger Patents Induce More Local Innovation? *Journal of International Economic Law* 7(2), 359-70.

Branstetter, L. G., R. Fisman, and C. F. Foley (2006). Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm-Level Panel Data. *Quarterly Journal of Economics* 121 (1), 321-349.

Branstetter, L. G., and Y. Nakamura (2003). Is Japan's Innovative Capacity in Decline? In Blomström, M. (ed.), *Structural impediments to growth in Japan*. Chicago, IL: University of Chicago Press. Also National Bureau of Economic Research Working Paper Series No. 9438.

Ciarli, T. and E. Giuliani (2005). Structural Reforms and Structural Change in Costa Rica. Industrial Dynamics, Structural Heterogeneity and Linkages: The Role of FDIs. English version of T. Ciarli and E. Giuliani, "Inversión extranjera directa y encadenamientos productivos en Costa Rica, in M. Cimoli (ed.), *Heterogeneidad estructural, asimetrías tecnológicas y crecimiento en América Latina*. Santiago, Chile: CEPAL/BID, vol. LC/W 35, 127-162

Chen, Y. (2008). Why Do Multinational Corporations Locate Their Advanced R&D Centres in Beijing? *Journal of Development Studies* 44 (5), 622-644.

Chen, Y., and T. Puttitanum (2005). Intellectual Property Rights and Innovation in Developing Countries. *Journal of Development Economics* 78(2), 474-493.

Cohen, W. M., Goto, A., Nagata, A., Nelson, R. R. and Walsh, J. P. (2002). R&D spillovers, patents and the incentives to innovate in Japan and the United States. *Research Policy* 31, 1349–67.

Mowery, D. C., R. R. Nelson, and B. Martin (2009). Technology policy and global warming. London, UK: NESTA Provocation 10.

Foray, D., and L. Hilaire-Perez (2001). The Economics of Open Technology: Collective Organization and Individual Claims in the "Fabrique Lyonnaise" During the Old Regime. In

C. Antonelli, D. Foray, B. H. Hall and W. E. Steinmueller (eds.), *Essays in Honor of Paul A. David*. Cheltenham, UK: Edward Elgar.

Fosfuri, A. (2004). Determinants of international activity: evidence from the chemical processing industry. *Research Policy* 33 (10), 1599-1614.

Ginarte, J. C., and W. G. Park (1997). Determinants of patent rights: A cross-national study. *Research Policy* 26 (3), 283-301.

Grossman, G. M., and E. L.-C. Lai (2004). International Protection of Intellectual Property. *American Economic Review* 94 (5), 1635-1653.

Hall, B. H. (2011). The Internationalization of R&D. In A. Sydor (ed.), *Global Value Chains: Impacts and Implications*. Ottawa, Canada: Foreign Affairs and International Trade Canada, Government of Canada, 179-210.

Hall, B. H. and C. Helmers (2010). The role of patent protection in (clean/green) technology transfer. *Santa Clara High Technology Law Journal* 26, 487-532.

Hall, B. H. and Ziedonis, R. H. (2001). The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor industry, 1979–1995. *RAND Journal of Economics* 32, 101–28.

Heald, P. J. (2003). Misreading a canonical work: An analysis of Mansfield's 1994 study. *Journal of Intellectual Property Law* 10, 309-318.

ICTSD and UNCTAD. (2003). *Intellectual Property Rights, Implications for Development Policy*. Geneva, Switzerland: ICTSD and UNCTAD Discussion Paper.

Ito, B. and R. Wakasugi (2007). What factors determine the mode of overseas R&D by multinationals? Empirical evidence. *Research Policy* 36, 1275-1287.

Javorcik, B. S. (2002). The composition of foreign direct investment and protection of intellectual property rights: Evidence from transition economies. *European Economic Review* 48, 39-62.

Kanefsky, J. and J. Robey (1980). Steam Engines in 18th-Century Britain: A Quantitative Assessment. *Technology and Culture* 21 (2), 161-186

Kanwar, S. and R. Evenson (2003). Does Intellectual Property Protection Spur Technical Change? *Oxford Economic Papers* 55, 235-264.

Kim, L. (2002). Technology Transfer and Intellectual Property Rights: The Korean Experience. *BRIDGES, ICTSD* 6 (8), November-December.

Kumar, N. (2003). Intellectual Property Rights, Technology and Economic Development: Experiences of Asian Countries. *Economic and Political Weekly* 38 (3), 209-226.

La Croix, S. J. and A. Kawaura (1996). Product Patent Reform and Its Impact on Korea's Pharmaceutical Industry. *International Economic Journal* 10(1), 109-124,

Lall, S. (2003). Indicators of the relative importance of IPRs in developing countries. *Research Policy* 32 (9), 1657-1680.

Lall, S. (2000). "Selective Industrial and Trade Policies in Developing Countries: Theoretical and Empirical Issues," Queen Elizabeth House Working Paper No. 48 (August).

Lall, S. (1996). *Learning from the Asian Tigers*. London: Macmillan.

Lanjouw, J. O. (1997). The Introduction of Pharmaceutical Product Patents in India: 'Heartless Exploitation of the Poor and Suffering'? Cambridge, MA: NBER Working Paper No. 6366.

Lederman, D. and W. F. Maloney (2003). *R&D and Development*. Washington, DC: The World Bank Policy Research Working Paper No. 3024.

Lee, J.-Y., and E. Mansfield (1996). Intellectual Property Protection and U.S. Foreign Direct Investment. *Review of Economics and Statistics* 78 (2), 181-186.

Léger, A. (2005). Intellectual Property Rights in Mexico: Do They Play a Role? *World Development* 33 (1), 1865-1879.

Lerner, J. (2002). Patent Protection and Innovation over 150 Years. *American Economic Review* 92 (2), 221-225.

Mansfield, E. (1986). Patents and Innovation: An Empirical Study. *Management Science* 32 (2), 173-181.

Mansfield, E. (1994). Intellectual property protection, foreign direct investment, and technology transfer. Washington, DC: International Finance Corporation Discussion Paper No. 19.

Mansfield, E. (2000). Intellectual property protection, direct investment and technology transfer: Germany, Japan and the USA. *International Journal of Technology Management* 19 (1/2), 3-21.

Maskus, K. E. (2004). Encouraging International Technology Transfer. Geneva, Switzerland: ICTSD and UNCTAD Issue Paper No. 7.

Maskus, K. E. and M. Penubarti (1995). How trade-related are intellectual property rights? *Journal of International Economics*, 39, 227-248.

McCalman, P. (2001). Reaping what you sow: an empirical analysis of international patent harmonization. *Journal of International Economics* 55 (1), 161-186.

Montobbio, F. (2007). Patenting Activity in Latin American and Caribbean Countries. Report for the project 'Technological Management and Intellectual Property' organized by the World Intellectual Property Organization (WIPO) and Economic Commission for Latin America and The Caribbean (ECLAC).

Montobbio, F. and V. Sterzi (2011). Inventing Together: Exploring the Nature of International Knowledge Spillovers in Latin America. *Journal of Evolutionary Economics* 21(1), 53-89.

Moser, P. (2005). How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs. *American Economic Review* 95 (4), 1214-1236.

Murmann, J. P. (2003). *Knowledge and Competitive Advantage: The Coevolution of Firms, Technology, and National Institutions.* New York: Cambridge University Press.

Nagaoka, S. (2006). Reform of Patent System in Japan and Challenges. In S. Nagaoka, M. Kondo, K. Flamm, and C. Wessner (eds.), *21st Century Innovation Systems for Japan and the United States.* Washington, DC: The National Academies Press.

Nuvolari, A. (2001). Collective Invention during the British Industrial Revolution: The Case of the Cornish Pumping Engine. Copenhagen, Denmark: DRUID, Copenhagen Business School Working Paper 01-05.

Park, W. G. (2008). International patent protection: 1960-2005. *Research Policy* 37 (4): 761-766.

Park, W. G., and J. C. Ginarte (1997). Intellectual Property Rights and Economic Growth. *Contemporary Economic Policy* XV (July), 51-61.

Park, W. G. and D. C. Lippoldt (2008). Technology Transfer and the Economic Implications of the Strengthening of Intellectual Property Rights in Developing Countries. OECD Trade Policy Working Papers No. 62. doi:10.1787/244764462745

Penrose, E. (1973). International Patenting and the Less-Developed Countries. *Economic Journal* 83 (331), 768-786.

Qian, Y. (2007). Do Additional National Patent Laws Stimulate Domestic Innovation in a Global Patenting Environment. *Review of Economics and Statistics* 89 (3), 436-453.

Ryan, M. (2010). Patent Incentives, Technology Markets, and Public-Private Bio-Medical Innovation Networks in Brazil. *World Development* 38 (8), 1082-1093.

Sakakibara, M., and L. G. Branstetter (2001). Do Stronger Patents Induce More Innovation? Evidence from the 1988 Japanese Patent Law Reforms. *Rand Journal of Economics* 32 (1), 77-100.

Scotchmer, S. (2004). The Political Economy of Intellectual Property Treaties. *Journal of Law, Economics, and Organization* 20 (2), 415-437.

Smith, P. J. (2001). How do foreign patent rights affect U.S. exports, affiliate sales, and licenses? *Journal of International Economics* 55 (2), 411-439.

Smith, P. J. (1999). Are weak patent rights a barrier to U.S. exports? *Journal of International Economics* 48 (1), 151-177.

Thursby, J. G., and M. Thursby (2006). *Here or There? A Survey of Factors in Multinational R&D Location*. Washington, DC: National Academies Press.

Turner, J. L., and P. Heald (2004). Intellectual Property and Foreign Direct Investment: Improving upon Mansfield's 1991 Survey, Preliminary Report. Atlanta, GA: University of Georgia. Available at http://media.terry.uga.edu/myila/pdf/RRTurner.pdf

Vallejo-Carlos, B. (2005). "Learning efforts in industrial firms and their effects on economic performance. The case of the automotive sector in Mexico," MERIT, University of Maastricht: paper presented at the Globelics Academy, Lisboa, May 2005, and the DRUID Academy Winter 2005 PhD Conference.

Van Pottelsberghe de la Potterie, B., and G. de Rassenfosse (2007). Per un pugno di dollari: A first look at the price elasticity of patents. *Oxford Review of Economic Policy*, 23(4), 588-604.

Yang, L. and K. E. Maskus (2009). Intellectual property rights, technology transfer and exports in developing countries. *Journal of Development Economics* 90, 231-236.

Zhao, M. (2006). Conducting R&D in Countries with Weak Intellectual Property Rights Protection. *Management Science* 52 (8), 1185-1199.