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A Review of the Empirical Evidence and Implications for Developing Countries

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DIW Berlin
German Institute for Economic Research
Mohrenstr. 58
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Tel. +49 (30) 897 89-0
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* DIW Berlin, Dept. International Economics and Humboldt University, Berlin, Chair for International Trade and Development, aleger@diw.de

Abstract

The role patents play for innovation is not clear, but patenting activity has increased in the last decades. This article reviews the empirical evidence on traditional and novel roles of patents to assess their impacts on innovation in developing countries. It shows that patents are not likely to support innovation in developing countries, even though their non-traditional functions fulfill important roles. This questions the relevance of domestic patent systems, and indicates the need to reassess the costs and benefits of the patent system, the use of patents as innovation indicators, and the need for more research on developing countries.

Keywords: Intellectual property rights; developing countries; innovation.

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1 Introduction

Patenting has increased in the last decades, which is puzzling when put in parallel with results from surveys on the effectiveness of patents as appropriation mechanisms. In several industries, patents do not provide strong incentives for innovation and are reportedly not an effective mechanism for firms to appropriate returns from innovation. Such a paradox could indicate that intellectual property rights (IPRs) are used for other purposes, whose effects on innovation should also be taken into account.

This is especially important since the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) of the World Trade Organization (WTO) sets minimum standards for intellectual property (IP) protection, which represents a strengthening of the rights for most developing countries. It states that

> *The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare (TRIPs Agreement, Art. 7, (WTO, 1995)).*

However, much of the empirical evidence available – mainly on industrialized countries – does not support the WTO's enthusiastic claims, while theoretical models yield contradictory predictions that are highly dependent on the assumptions made. Hence this article contributes to the literature on innovation by systematically reviewing the empirical evidence on the different functions of patents and deriving the implications for developing country innovation. This article has three objectives:

- to assess the impact of patents on innovation in industrialized and developing countries through their different functions;
- to identify areas for further research on innovation and IPRs;
- to provide policy advice on innovation and intellectual property policy in developing countries.

It finds that patents do not provide strong incentives for innovation, but that their new roles – definition for technology transfer, strategic uses, securing access to markets,

and signaling reputation – are increasingly important in industrialized countries. Little empirical evidence exists for developing countries but, taking into account their characteristics, patents are even less likely to support innovation there. Lower levels of technological development and malfunctioning or inexistent markets for technology and financial and human capital can seriously impede the conduct of innovation, and these obstacles are not to be overcome by the use of patents. However, the additional roles of patents (e.g., signaling, definition) might be especially important in developing countries given imperfect markets for technology and technology inputs.

This evidence points to the need to reassess the role and the costs and benefits of patents taking their new functions into account. In general, more empirical research needs to be focused on IPRs and innovation in developing countries, to better understand the functioning of IPRs in different settings, and to be able to develop more appropriate policies supporting innovation in these countries.

The next section presents the characteristics of developing countries with respect to innovation. Section 3 reviews the evidence on the traditional functions of IPRs. Section 4 examines the "patent paradox" and explores other roles IPRs could play. Section 5 discusses the lessons learned from the literature and the implications for developing country innovation, and section 6 concludes.

2 Defining Developing Countries

Despite differences in the levels of development, a certain consensus exists on the main features of the economic environment in developing countries (LDCs). The institutional environment is characterized by the presence of high transaction costs, which often include corruption (Collier, 1998), and by weak institutions (Stiglitz 1989). Markets are often incomplete, weak or non-existent (Lall, 1995), which, for certain areas such as risk, financial and human capital and information, has important implications for the performance of innovative activity (Juma, 1999). These markets are often characterized by their duality: often research organizations and multinational companies operating at the technology frontier coexist with micro-enterprises having little technological capacities (UNCTAD, 2006). Very few links exist between these segments, which makes the transmission of information and spillovers difficult (Cimoli et al., 2005).

The standards of education and innovative ability vary among countries, thus making some countries not only more capable of innovating but also of absorbing information from transfers and spillovers (Cohen and Levinthal, 1989). Several LDCs have low innovative capabilities and are dependent on industrialized countries for the provision of new technology and knowledge (Aubert, 2005).

Given the low level of economic development and the unequal distribution of income, the effective domestic demand is usually small[1] (Foellmi and Zweimüller, 2006). The demand side is often neglected but the expansion of domestic demand is critical for economic growth, and for the performance of innovation addressing local needs (UNCTAD, 2006). Small countries can however innovate for export markets to overcome such limitations (e.g., Nokia in Finland, and more generally the performances of Israel, Ireland and Singapore).

Finally, agriculture is still a critical sector to get development going (Lipton, 2005). If the sector is linked to the rest of the economy, a virtuous circle of demand for agricultural products stimulating entrepreneurship and investments in non-agricultural activities would have the potential to contribute to sustainable poverty reduction. However, agricultural production is constrained by limited resources – land, water – which implies that productivity increases are heavily dependent on yield increases – technological change – in this area (De Janvry et al., 2005).

3 IPRs: Incentives for Innovation

3.1 Background: Innovation and intellectual property rights

Innovation can be defined as an array of scientific, technological, organizational, financial, and commercial activities necessary to create, implement, and market new or improved products or processes[2] (OECD, 1997). The innovation process results in not only a new product or process, but also new information that has public good characteristics (non-rival and non-excludable). These two properties of information make the gains from innovation difficult to appropriate, which implies that research

[1] Obvious exceptions are large countries such as India, China and Brazil.

and development (R&D) opportunities that would be socially profitable are not exploited because they are privately unprofitable (Alston and Pardey, 1999). In order for innovation to be undertaken, incentives need to be given. IPRs represent a possible government intervention to correct for this market failure.[3]

With IPRs arises the dilemma of "access versus appropriability" (Alston et al., 1995). By granting temporary exclusive rights on inventions, patents are intended to allow the right-holders to price their products above marginal cost, and hence recoup their initial research investment. Such exclusive rights create incentives for the performance of R&D leading to innovation. In exchange for the exclusive right granted, the patent applicant is required to disclose the details of his invention. However, monopolies that are not regulated can create inefficiencies: too little of the protected good is produced, and its price is too high. IPRs hence create a trade-off between dynamic gains, due to the improved innovation incentives, coupled with static losses due to the restricted use of the innovation (Moschini, 2004).

Two main types of IPRs exist: industrial property, and artistic and literary property. I consider herein patents, given the focus on technical innovation.[4]

3.2 Disclosure

Theoretically, a critical advantage of offering patent protection is that society benefits from the disclosure of new information, the assumption being that, in the absence of patents, companies would keep their innovations secret to appropriate the associated returns. In practice, the use of patent applications as a source of information does not appear to have the same importance in all countries.

For American and European innovative firms, patent applications are the second-least important source of information[5] (Arundel, 2001; Levin et al., 1987). Diffusion of

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[2] I concentrate here on technical innovations, for which industrial property rights are relevant, and leave aside other types of innovation (e.g., management, services) that can also be important for economic development.

[3] Other interventions can include trade secrets, tax breaks on the performance of R&D, contests or public performance of R&D. See Wright (1983) for a comparison of public interventions in the research market.

[4] Copyright is also considered important for innovation in the software industry, see CIPR (2002) chap. 6. Other IPRs, such as trademarks and geographic indications, can also support innovation but they act rather as marketing tools (Perrin, 1994) and will therefore not be considered in the discussion.

[5] Arundel suggests consultants, patent disclosures, public research, conferences and journal, competitors, trade fairs, suppliers, and customers as potential information sources, while Levin and others

information from patent applications is much more important in Japan (Pitkethly, 2001) where the characteristics of the system – first-to-file rule of priority and existence of a pre-grant opposition period – care for the earlier disclosure of the information and provide incentives for companies to monitor competitors' applications (Cohen et al., 2002). No evidence has been found on LDCs.

Yet, French firms identified the disclosure requirement as a major disincentive to patent (Duguet and Kabla, 1998): keeping proprietary information secret is important, since infringement, especially of process innovations, might be difficult to detect. Indeed, inventors have an incentive to disclose as little information as possible in their application, to retain critical information (Macdonald, 2004).

The usefulness of this information depends on a firm's level of absorptive capacity, that is, its ability to exploit outside information (Cohen and Levinthal, 1989). The firm's knowledge or know-how (tacit, embedded) is especially important in that respect (Mansfield et al., 1981) and is not acquirable in patent applications. The codified information therein is often not sufficient for a firm lacking the tacit knowledge to exploit it (Penrose, 1973). However, for countries like Japan, scanning of patent applications is important to build technological capacities (Granstrand, 1999).

The disclosure of information necessary to obtain patent protection does not really seem to benefit society by supporting innovation. Institutional characteristics are important but the evidence available indicates that, in most countries, firms do not consider it an important source of information. It is likely to be even less important for at-the-frontier inventions in LDCs, where firms generally have lower levels of absorptive capacity.

3.3 Appropriability

Early evidence (Scherer et al., 1959) suggests that the patent system might not be effective in ensuring appropriability and inducing innovation. For example, patent protection was essential for 60% of the R&D performed by the pharmaceutical indus-

propose licensing technology, patent disclosures, publications or technical meetings, conversations with employees or innovating firm, hiring employees of innovating firm, reverse engineering of production and independent R&D.

try, for 15% of the chemical industry's R&D, and for 5% in the mechanical engineering industry (Taylor and Siliberston, 1973).

Evidence from US manufacturing firms (Levin et al., 1987) shows that patents are rated the least effective mechanisms of appropriation[6] for new processes, and the second-least for new products. The effectiveness of patents is higher for industries in which imitation costs and time are low (drugs, pesticides and chemical industries). A follow-up survey (Cohen et al., 2000) finds patents to be the second-least effective appropriability mechanism[7], and firms in most industries rely on more than one mechanisms to protect their innovations. However, for R&D-intensive industries such as drugs and medical equipment, patents are effective for 50% and 55% of the products, respectively, but these figures are not very far from the effectiveness of other non-legal mechanisms. This is consistent with early findings (Taylor and Siliberston, 1973) presenting evidence that patent protection has a strong and pervasive influence of the willingness to perform R&D in the chemical and pharmaceutical industries, but is not important in most other industries.

In Europe, lead time and secrecy reportedly are always more important than patents as appropriation mechanisms for product and process innovations[8] (Arundel, 2001). Similar results are reported for Switzerland (Harabi, 1995), Australia (McLennan, 1995 cited in Arundel, 2001), Canada (Baldwin et al., 2002) while in Japan lead time (but not secrecy) is more important than patents for product innovation – both are more important than patents for process innovation (Cohen et al., 2002). Conversely, in France the patent system confers valuable property rights to inventors, even if the distributions of patent values are highly skewed and differ across sectors. On average, their private value would be equivalent to a 15-25% R&D subsidy, hence providing substantial incentives for R&D (Schankerman, 1998). However, other strategies to appropriate returns from innovation still play an important role.

Evidence available from LDCs is scarce. In Mexico, patents are not considered effective in securing appropriation of benefits from innovation in the maize breeding in-

[6] The other mechanisms of appropriation listed are secrecy, lead time, learning curve advantage and sales or services efforts.

[7] Other mechanisms of appropriation listed are secrecy, other legal measures, lead time, complementary sales and services, and complementary manufacturing capabilities. The effectiveness measure is based on the proportion of innovation for which the mechanism is considered effective.

dustry (Léger, 2005). In general, patents are not the preferred appropriation mechanism, for both product and process innovations, across countries. Where survey evidence is available, patents are considered to be an effective appropriability mechanism only for a few industries. The little empirical evidence available for LDCs examines the plant breeding industry, subject to special characteristics –by buying the invention, one can reproduce it – which could bias the results. In these countries, the enforcement of the rights is often a problem.

3.4 Studies on Innovation

One can use either input indicators – such as R&D investments, number of researchers – or output indicators – patent applications, sales, improvement of quality of the goods produced – to account for the change in innovative activity. I consider each category in turn.

3.4.1 Studies Using Input Proxies

Cross-country panel studies looking at the determinants of innovation (proxied by R&D intensity) identify IPRs as a significant and positive factor (Kanwar and Evenson, 2003; Lederman and Maloney, 2003; Varsakelis, 2001). None of these studies controls for the general quality of institutions in the countries, which could be captured by the IPRs index. Moreover, the possible endogeneity of the IPRs variable is addressed only by Lederman and Maloney (2003).[9] The situation in the agricultural sector is similar: IP strength is an important determinant of private R&D investments in OECD countries, given the quality of the institutional environment (Alfranca and Huffman, 2003).

Data on innovation at nineteenth century world fairs show no evidence of increased levels of innovative activity in countries with patent protection (Moser, 2005), but innovative activity tended to be more diversified in these countries. Conversely, in countries without patent laws, inventors focus more on industries where patents are

[8] European countries considered are Norway, Belgium, the Netherlands, Luxembourg, Ireland, Denmark, and Germany.

[9] Ginarte and Park (1997) build an index of IP protection based on different indicators (membership in international treaties, enforcement, etc). The authors then look at the determinants of patent rights and find R&D investments to be an important explanatory factor.

not important. Though this could be endogenous, there is little evidence of organization and lobbying during the period studied: Lobby groups representing domestic interests, and international patent treaties, representing foreign lobby groups' interests, emerged towards the end of the 19th century. Lerner (2002, 2004) uses historical patent data from 60 countries over 150 years to study the impacts of shifts in patent policy. Strengthening patent protection generally led to a decrease in patent applications – both domestically and in Great Britain, the major foreign technology market (where patent policy stayed relatively stable over time), which would imply that stronger patent protection did not spur innovation. This result is puzzling but robust to several specifications, and is consistent with results from case studies of policy changes. However, the limited availability of data (e.g., R&D investments) does not allow testing for possible explanations such as a general decrease in investments, or in the productivity of R&D.

In Japan, neither the first nor the second patent reforms has caused significant increases in R&D spending or innovative output (Branstetter and Nakamura, 2003; Sakakibara and Branstetter, 2001). The authors find that the results of the first study are due to the lack of communication between company patent offices and researchers – the change in patent laws was communicated to patent officers but not to scientists, who hence could not react to the strengthening – while the second study concludes that strengthening IP protection was not a sufficient condition for supporting innovation, given the nature of R&D taking place (e.g. applied rather than basic innovation). In the Canadian manufacturing industry, the causal relationship between patents and innovation is found to be much stronger going from innovation to patents than the other way around (Baldwin et al., 2002). Establishing the direction of causality using econometric techniques is difficult, and the evidence presented rather indicates that firms using other appropriation methods are more likely to innovate than those using patents.

Early case study evidence from Brazil (Frischtak, 1989) shows that the IP regime was not related to the local technological "effort" nor did it affect innovation. Likewise, it was impossible to relate the strengthening of IPRs in Mexico to the increase in the number of maize breeding programs, of breeders in the industry or to the change in R&D budgets (Léger, 2005).

3.4.2 Studies Using Output Proxies

Policy choices such as IPRs strength and outward orientation are factors affecting innovation (proxied by international patents)[10] in OECD countries (Furman et al., 2002). Applying this framework to five East Asian countries yields different results: IPRs is not a significant factor explaining innovation there (Hu and Mathews, 2005). Similar results obtain when using patent applications in the US to identify the determinants of innovation in three different samples: LDCs, industrialized countries, and the pooled sample (Higino Schneider, 2005). The level of IP protection is a positive and significant factor explaining innovation in the full sample and in the industrialized countries sub-sample but is not significant or negative in the LDCs sub-sample. A study of the Indian pharmaceutical industry (Lanjouw and Cockburn, 2001) concludes that the rise in international patenting occurring cannot be strongly related to the anticipated strengthening of IPRs. Furthermore, Chaudhuri (2005) shows that the patent regime along with unsupportive industrial policy, explain the decline of the Indian industry in the 1950s and 1960s. In 1970 a new Patent Act allowed to patent processes for the creation of pharmaceutical products, but not the products themselves,[11] following which the domestic industry grew, resulting in the multinational companies losing their market domination.

The empirical evidence on the role of IPRs for innovation is clearly mixed. From section 3.3 it is clear that the importance of IPRs varies across industries, therefore the results of cross-country econometric studies represent an average effect of probably conflicting evidence. Taking this heterogeneity into account would be more informative. The mixed results from industry case studies illustrate this point. It is however difficult to assess the differential impacts of IPRs for developing and industrialized countries since there is so little evidence available. More evidence is needed on other industries and on LDCs in general.

Another problem relates to the measurement of innovation. For several LDCs it is not possible to separate public and private R&D investments, which is likely to bias the results given that IPRs should provide incentives for private R&D. In countries for

[10] They define international patents as patents granted to foreigners by the US Patent and Trademark Office (USPTO) and US patents granted to US firms or government establishments.

[11] The Act also allowed only one process patent per product and reduced the duration of pharmaceutical patents to a maximum of 7 years.

which data are available, private R&D investments are a lot smaller in LDCs: private R&D represents on average 60% of total R&D investments in industrialized countries, whereas it represents 37% in LDCs[12] (UNESCO, various years). The quality of the data – i.e., what it measures exactly – is also dubious.

Conversely, a problem with using US patent applications or granted patents is that this variable could be highly correlated with the export structure of the country (Blind et al., 2006), which most authors do not control for. Furthermore, this might not be an appropriate measure for LDCs, where costs of obtaining a patent might be too high for inventors, or where innovations might not qualify for patent protection.[13] Domestic patent applications might be a better proxy but the quality of the patent system and the costs of patent protection have to be controlled for.[14]

From this discussion, one can conclude that patents do not necessarily provide incentives for innovation. Interestingly, patent applications increased in the last decade, as can be seen from figures 1 and 2. The next section examines the potential reasons behind this increase.

4 IPRs: Other Roles

4.1 The patent paradox

The patent paradox (Hall and Ziedonis, 2001) describes the contrast between the relative ineffectiveness of patents, reported in various surveys, and their increasing use. Using international patent data to explore the reasons behind this upsurge[15] Kortum and Lerner (1999) reject the "friendly-court" hypothesis, defined as a reaction to the institutional changes affecting the American IP protection system. Though patenting increased faster in biotechnology and software, these two sectors do not drive the upsurge in patenting. Contrary to the "regulatory capture" hypothesis, where established firms patent more to secure their power, the role of smaller and less frequent

[12] Data are not available for the whole sample of LDCs, hence the real average might be lower.

[13] For a discussion on adequate measures of innovation see e.g., Griliches (1994).

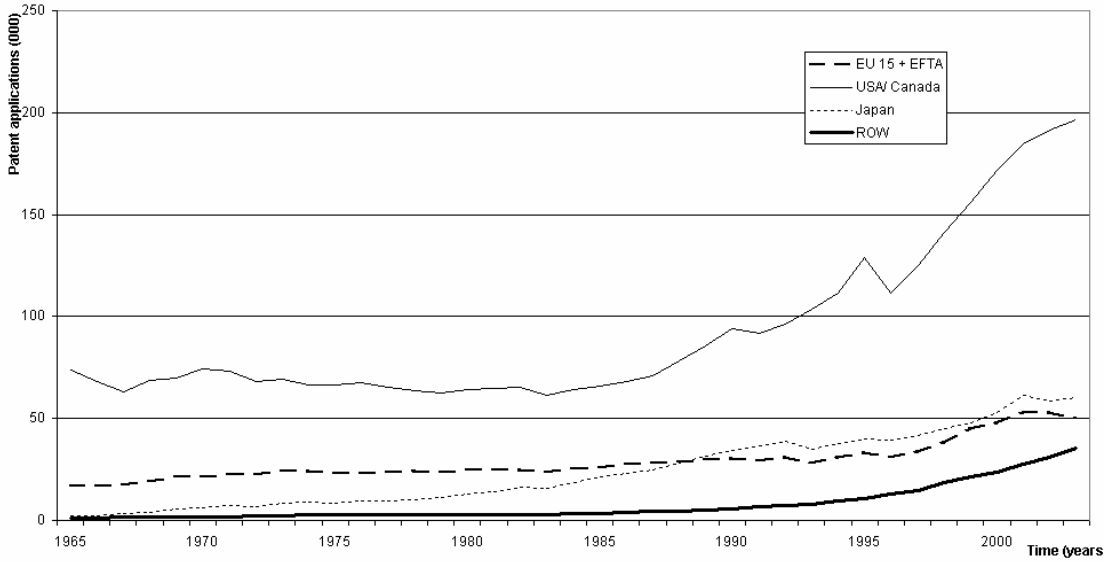
[14] Koo et al (2006) show how the cost of obtaining and maintaining plant variety protection is high in China compared to the US. A similar situation could prevail for patents.

[15] The authors use patent applications in the US, Japan, France, Germany and the United Kingdom from inventors from these different countries.

patentees has increased, and the R&D behavior contradicts a possible increase in R&D productivity. The authors conclude that the increase in patenting was due to a change in the management of innovation, including a shift to more applied activities. In the semi-conductor industry (Hall and Ziedonis, 2001), where patents are considered one of the least effective mechanisms to appropriate returns to R&D (Cohen et al., 2000; Levin et al., 1987) and the propensity to patent increased since the early 1980s, the increase in patenting is mainly related to strategic concerns: Firms patent in order not to be blocked by competitors and to increase their negotiation power. In the software industry, Bessen and Hunt (2004) find that there is a negative relationship between patenting and R&D investments, which they explain by the increasing prevalence of strategic patenting. Yet patent policy concerning the software industry underwent several policy changes recently, hence these results might represent a short-run reaction rather than the true relationship. In Europe, the patenting surge occurred a bit later: the number of patent applications submitted to the European Patent Office almost doubled between 1989 and 2000 (Harhoff and Reitzig, 2004), but no comparable study on the phenomenon has been conducted yet.

Figure 2 shows the number of patent applications from selected (advanced) LDCs to the USPTO. The number of applications from Chinese and Indian inventors starts rising sharply at the end of the 1990s, while in other countries the increase is more gradual. Even though their participation is still modest, non-OECD countries submitted 6.4% of all patent applications to the USPTO in 2002, and were awarded 5.1% of all patents granted. The reasons behind this increase, and in general the reasons for patenting in LDCs have not been investigated. The studies reviewed so far hint to the fact that patents could fulfill several functions. The following sections examine the alternative roles patents can play.

Figure 1 **Patent applications in the USA, 1965-2003**



Source: USPTO (2005)

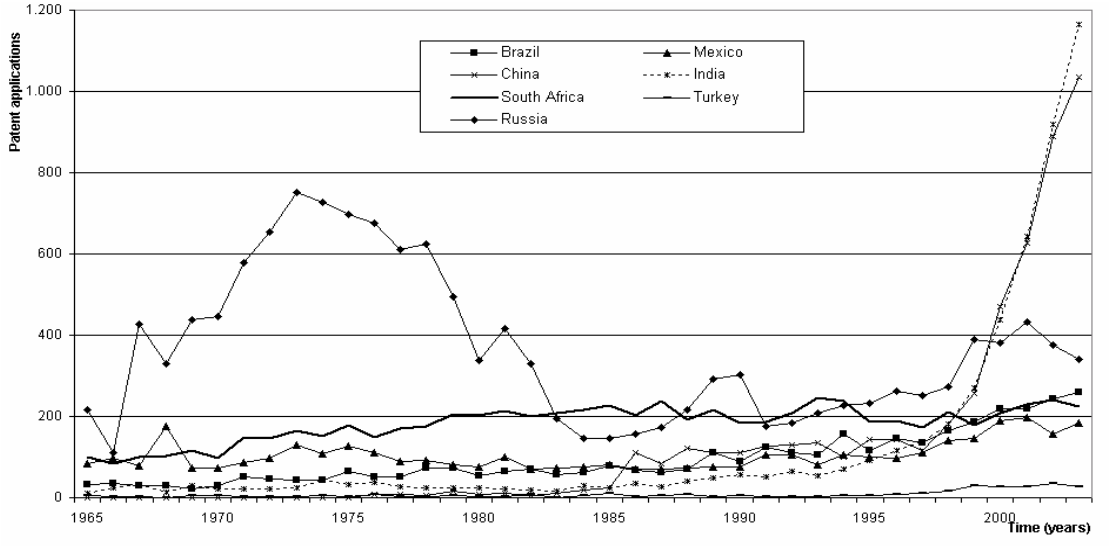
4.2 Earning of licensing revenue and the disclosure paradox

IPRs play an important role, since they solve what Arrow called the paradox of disclosure (Arrow, 1962; Bar-Gill and Parchomovsky, 2005). Information that is not afforded legal protection cannot be traded on the market, since in order to sell the information, the inventor must disclose it – but then has nothing left to sell. Patents hence favor the emergence of markets for technological exchange and the reduction of transaction costs in these markets (Gallini, 2002).

Even if the value of licensing revenue is one of the least important reasons for patenting (Blind et al., 2006; Cohen et al., 2000; Levin et al., 1987) IPRs are important for transferring technologies. Early evidence on the strength of IPRs worldwide shows that US firms are likely to obtain higher receipts of royalties – and higher payments of license fees – with stronger IPRs in partner countries (Ferrantino, 1993). Later evidence (Branstetter et al., 2006; Park and Lippoldt, 2005) also supports these results, for both affiliated and unaffiliated firms. Stronger IPRs in the host country would also increase the likelihood of licensing compared to exports from the US (Smith, 2001). These results are consistent with early evidence showing that patent strength of a nation attracts licensing (Contractor, 1984) or affects firms' decision to transfer technology, and the type of technology transferred (Lee and Mansfield, 1996; Mansfield, 1995a; Mansfield, 1995b). However, the impact tends to vary following the initial

strength of protection: stronger patent laws would have a positive and significant effect on both absolute and relative flows of US receipts of arms' length royalties when the initial degree of patent protection is higher than a critical value (Yang and Maskus, 2001).

Figure 2 **Patent applications in the USA for selected countries, 1965-2003**



Source: USPTO (2005)

The importance of IP protection also varies across industries: high-technology manufacturing and chemicals are the sectors most oriented towards licensing, and the likelihood of licensing increases with the strength of patent protection (Nicholson, 2007). Anand and Khanna (2000), using data on international licensing contracts, also find that licensing in the chemical and pharmaceutical industries depends on patent protection, while it would not be important for the semi-conductor industry, which they relate to the differences in contract design. Conversely, firm-level data from the chemical industry hints to a negative or non-significant impact of patent rights on licensing (Fosfuri, 2004). In the pharmaceutical and chemical industries, firms would transfer technology only to countries with a certain level of IP protection, but in other industries the level of IP protection determines the type (old vs. new) of technology transferred (Mansfield, 1995a; Mansfield, 1995b).

In general, the strength of IP protection does affect the decision to license, or the type of technology licensed, and a system of definition and protection of information is necessary for transfers and licensing to take place. In this respect, the existence of

IPRs is important for the diffusion of new information, and especially so for LDCs, often dependent on foreign technology.

4.3 Strategic uses: Blocking competition and improving bargaining position

Interestingly, even if the surveys cited above reveal that patent protection is not an effective method to appropriate returns to R&D activities, the most important reason for patenting mentioned in surveys is almost always to prevent imitation from competitors (Arundel, 2001; Blind et al., 2006; Cohen et al., 2000; Cohen et al., 2002; Duguet and Kabla, 1998). However, strategic uses of patents seem to be increasing in importance (Macdonald, 2004).

Strategic uses can be separated into two categories: (1) patents to block other firms from patenting an invention and to prevent infringement, and (2) patents to use in negotiations in cross-licensing, that will be discussed in turn.

4.3.1 Patents to block competition or to prevent infringement

The function of blocking is to create a wide space around an innovation where other firms cannot develop a competitive alternative. This is consistent with the idea of patent granting a "prospect" right (Kitch, 1977). This space can be created either by a single patent with a broad scope or by creating patent families that cover a wide technology space (Arundel and Patel, 2003). In order to prevent infringing on patent rights, competitors might avoid innovating and producing in areas where such a situation prevails (Lanjouw and Lerner, 1998). Evidence on patent litigation shows that the ability to gain from subsequent improvements depends on the control of a basic technology (Lanjouw and Schankerman, 2001). Again, such aspects do not seem to have been investigated for LDCs. Given the evidence that (large) foreign-owned firms tend to negatively affect the productivity of domestic firms (Aitken and Harrison, 1999) such behavior in LDCs could have negative effects on local innovation.

Patents can also be used defensively to prevent infringement suits, especially for complex inventions – composed of several separately patentable elements (Cohen et al., 2002). Still, patents to prevent infringement might not be effective if competing

firms in the industry use "patent flooding"[16] (Sankaran, 2000). Hearings recently took place concerning a related phenomenon, that of "patent trolls"[17] (SCIIP, 2006), that obtain patents of dubious merit and then use lawsuits to extract settlements, sometimes long after a technology as become standard or widely adopted in an industry (Hall and Ziedonis, 2007). While small businesses, especially those not performing R&D, would have incentives to "troll" (Reitzig et al., 2007), there is still little research on these activities.

In general, patents are important strategic assets for firms, and while in certain cases patenting can support innovation (e.g. for cross-licensing and collaborative R&D) in other situations it could slow down the rate of innovation by keeping innovative firms from working in some areas – the aggregate impact is hence difficult to evaluate, be it in industrialized or LDCs.

4.3.2 Patents as bargaining chips

For new entrants, such blocking patents can act as an effective barrier to entry. For more mature firms, it is where a patent portfolio becomes important. For French manufacturing firms, the use of patents in technology negotiations is the second-most important reason for patenting (Duguet and Kabla, 1998) and Bellais and Guichard (2006) find that patents act as trading currency between partners in the French defense industry. In the Netherlands, too, the participation of a firm in collaborative R&D is a significant factor affecting the probability to patent (Brouwer and Kleinkrecht, 1999). Patents are used by firms to protect existing technology when entering a new research joint venture – such patents are important for negotiating research partnerships – and to protect the inventions resulting from the collaboration (Hertzfeld et al., 2006). However, patents would not be necessary for collaborations to happen. In Taiwan R&D collaborations between firms and research institutes at different levels of technological development have been critical for increasing average technological capacities in the country, but IPRs were not particularly important for the formation of these consortia (Mathews, 2002). They aimed at technological learning, upgrading and

[16] The "flooder" patents several incremental inventions based on a technology to surround the owning firm so that it cannot exploit its technology without infringing on the flooder's rights. The flooder is also unlikely to be able to exploit his patents without infringing.

[17] The definition of patent trolls is still unclear and at times also includes patent owners that focus their business on the enforcement of IPRs. These could be rather termed "patent enforcers" as their activities is a legal practice and could actually ease technology transfers (LaPlante, 2006)

catch-up, as well as overcoming small firms' diseconomies of scale, hence fast diffusion of public sector technologies was promoted above appropriation concerns.

Strategic aspects are very important in Japan, where intra-industry spillovers and patent density are high[18] (Pitkethly, 2001). There are more patents per innovation, which renders patent holders more interdependent (Cohen et al., 2002) and gives an additional incentive to patent.

Such proliferation of IPRs is what some are afraid could lead to a "tragedy of the anticommons" (Heller and Eisenberg, 1998), where multiple owners each have the right to exclude others and no one has an effective privilege of use. Combined to high bargaining and licensing costs, and stakeholders' strategic behaviors, the authors conclude that an anticommons situation could happen in their field (biomedical research). However, recent evidence (Walsh et al., 2006) does not support their claims. Only 1% of academic respondents in the biomedical field postponed a project for more than a month due to patented knowledge inputs, and none of the respondents ever stopped a project for this reason. However, these results appear to be mainly due to the academic researchers' ignorance of patent issues.

Conversely, an anticommons situation could be emerging in the Indian plant breeding industry (Ramanna, 2003), where several actors started asserting rights over resources in the public domain (e.g. genetic resources, traditional knowledge, indigenous practices), and patent application on plant varieties are increasing and more generally in the biotechnology industry, where patent density has increased along with the complexity of the technologies used. Freedom to operate concerns supported the wave of mergers among biotech firms in the late 1990s (Lesser, 1998). However, several critical biotechnology research inputs are not patented in LDCs (Attaran, 2004; Binenbaum et al., 2003).

In general, the use of patent for strategic purposes has not really been investigated so far, theoretically nor empirically, and potential impacts on innovation are difficult to predict. Among other factors, it could depend if the patented technologies are substitute or complements: cross-licensing of complementary patents supports innovation,

[18] Typically, granted Japanese patents tend to cover fewer claims than European and American patents.

but for substitutable patents there might be no impact.[19] However, as transaction costs are usually important in LDCs, blocking patents might render innovation easier – by securing a free area for research – and conversely, patents as bargaining chips might complicate innovation and make it more costly.

4.4 Patents to secure investments

According to early evidence (Scherer et al., 1959), firms find that patents protect investments in R&D and represent a means to preserve returns on investment, but that they do not, of themselves, provide incentives for innovation. Baldwin and others (2002) conclude that, in the Canadian manufacturing industry, the causal relationship between patents and innovation is actually much stronger going from innovation to patents than the other way around. It is however difficult for interviewees to abstract from the existence of the patent system, and even if patents by themselves do not provide incentives for innovation, they could still affect the decision to undertake R&D in the first place. Still, Greasly and Oxley (forthcoming) reach a similar conclusion concerning the relationship between patenting and innovation during the industrial revolution in Great Britain, which leads them to conclude that patents are not an appropriate measure of technological progress for the period 1760-1851.

Conversely, Mansfield (1986) finds that patents were not necessary for the commercial introduction of most inventions (around 65%) in his dataset. These figures are even more striking if chemical and pharmaceutical companies – for which patents are especially important for commercialization – are taken out of the sample: between 80 and 90% of inventions would have been introduced in the absence of patents. However, the dataset used is small (100 firms from different industries) but these results shed an interesting light on the issue.

Recent evidence points to the importance of risk for innovation (Fosfuri, 2004) and Czarnitzki and Toole (2006) find that R&D investments by non-patenting firms fall in response to uncertainty (proxied by revenue volatility) while firms with patents show no response. The case of "patent enforcers" i.e., firms or individuals that enforce a

[19] Empirical evidence on patent pools (Lerner et al, 2003) shows that the more complementary the included patents are, the more a patent pool support innovation, and conversely.

patent without practicing the invention[20] could also represent a risk-reducing strategy. Indeed, the enforcement of the patent and the possible collection of licensing fees might reduce risk in innovative industries, by giving firms an opportunity to "cash in" the value of their intellectual assets if needed. There does not seem to be empirical evidence available on this phenomenon, even though it has been observed (e.g., Levi Strauss' efforts to protect its trademarked design in February 2007, Texas Instruments' lawsuits against Japanese semi-conductor firms).

There is still little empirical evidence on the interaction of risk and IPRs for innovation but if these results are solid, patents could play an important role for innovation in LDCs, where the economic environment is often riskier and characterized by uncertainty.

4.5 Access to foreign markets: Trade and FDI

The inclusion of IPRs in the WTO was necessary given the increasing value of ideas and knowledge in trade, and has supported the emergence of a body of empirical research examining the link between IPRs and trade, and FDI.

4.5.1 IPRs and Trade

Using the adherence to an international IP treaty as a proxy for stronger IP protection, Ferrantino (1993) finds that stronger IPRs have no impact on US exports to a country. Conversely, stronger patent laws attract larger than expected flows of imports from OECD countries to large LDCs (Maskus and Penubarti, 1995), supporting the idea that exporting firms discriminate across export markets on the basis of patent laws. Substantial increase in trade volumes would derive from stronger IP protection (Smith, 1999), a result robust to different IP proxies.[21]

However, IP protection levels would not affect US and German international transactions in manufacturing industries (Fink, 2005) and trade in high-technology goods would not be responsive either to IP protection (Fink and Primo Braga, 2005). In South Africa (Al-Mawali, 2005), total intra-industry trade in the country does not

[20] Such patent enforcers can also fall under the broad definition of patent trolls, see note 18.

[21] Smith uses both the Rapp and Rozek (1990) and the Ginarte and Park (1997) indices. The R&R index measures the conformity of national patent laws in 1984 with minimum standards proposed by the

depend on commercial partners' IP protection levels but on the interaction between the partners' IP strength and their imitative capabilities. No other evidence has been found on developing country trade patterns and IP protection.

4.5.2 IPRs and FDI

Empirical evidence on the relationship between IPRs and FDI is varied and contradictory. A first study (Park and Lippoldt, 2003) finds IP protection to be positively associated with FDI and less so with trade and the variation in FDI in response to a strengthening of IPRs is stronger where IP protection is the lowest. In the same line of thought, increasing IPRs from a relatively low base would increase the attractiveness of licensing relative to FDI in a given country, but beyond a certain IP protection level, the likelihood of FDI relative to licensing increases again (McCalman, 2001). Using diverse measures of IP protection, Park and Lippoldt (2005) and Nicholson (2007) find the opposite: stronger patent rights would increase the likelihood of licensing with respect to FDI, for both industrialized and LDCs. Anecdotical evidence from the Indian pharmaceutical industry (Chaudhuri, 2005) also points in this direction: following the liberalization of the industry in the 1990s and the expected strengthening of IPRs after TRIPs, multinational companies started closing their plants in India and instead license production to domestic firms.

These results show how important the modeling choice is: McCalman uses a bivariate probit model to estimate the likelihood of FDI decision (with respect to licensing) whereas Park and Lippoldt estimate the relationship between IP protection and royalties and licensing fees. Nicholson (2007) uses two equations: one using FDI per industry and country, and the second one licensing per industry and country, and controls for the level of development. This is important, but the original level of IP protection could also be controlled for. Kumar's results (1996; 2001) show that strong IP protection positively affects the probability to attract R&D investments and FDI from US and Japanese multinational enterprises into industrialized countries, but not into LDCs. The type of FDI taking place should also be taken into account: for distribution activities, IPRs do not really matter, whereas they grow in importance with the level

US Chamber of Commerce, whereas the G&P index weighs a subset of conditions describing aspects of IP protection. There is a strong positive correlation (0.75) between the two indices.

of technology and the type of activity (production, R&D) taking place in the host country (Javorcik, 2004a).

The evidence on trade, FDI and IPRs is mixed and broadly points at critical factors that need to be taken into account. Heterogeneity with respect to the type of activity, the type of industry and the level of development should all be considered.

4.6 Signal for reputation

Patents can also be used to measure the performance of a firm's employees, even though this use is not considered very important. For European (Arundel, 2001; Duguet and Kabla, 1998) and American firms (Cohen et al., 2000) the use of patents for evaluating researchers is the least important reason for patenting, while it is the second-least important reason for patenting in Japan (Cohen et al., 2002). Scherer and others (1959) find that patents are also a source of prestige to inventors, which could also be used to signal their own quality. There is no evidence on the use firms in LDCs make of patents as an evaluation device.

Patents would help signal a firm's expertise for two main purposes: to obtain financing and to attract research partners (Mazzoleni and Nelson, 1998). Patent data offer a way to establish the value of a start-up company, a difficult endeavor when much corporate value is intangible (Macdonald, 2004). In the surveys mentioned above (Arundel, 2001; Blind et al., 2006; Cohen et al., 2000; Cohen et al., 2002; Duguet and Kabla, 1998) the importance of signaling to acquire financing on the stock market or to increase the value of the firm is listed as one of the important reasons for patenting. Patents are more important for small firms (Blind et al., 2006) and especially so for R&D-performing small firms (Arundel, 2001). However, the value of IP[22] varies significantly across sectors (Greenhalgh and Rogers, 2006).

Hall (2004) observes a similar phenomenon when it comes to signaling reputation to attract research partners. For incumbents, the patent portfolio has little impact on market value, since past R&D activities already give a good indication of the technological capabilities, but for entrants, a patent portfolio signals the technological level, which can be instrumental for establishing collaborative R&D.

[22] The authors consider the value of patents and trademarks.

Another strategy to build reputation would be through litigation against infringement. It sends a strong signal to other firms concerning the capacities of the firm, but also about the value of the patents and its validity. This "publicity" leads to higher citations for litigated patents in subsequent applications (Lanjouw and Schankerman, 2001).

Patents fulfill a signaling function for the acquisition of financing or the establishment of R&D collaborations. While no evidence has been found on LDCs, it can be assumed that patents play a similar or even more important role in these countries. Indeed, in countries where transaction costs are high, international patents (e.g., US, EU, Japanese) could prove to be a reliable source of information, especially for international collaborations. Domestic patenting is probably not relevant for innovations with an international potential, and their value for the domestic market might be limited. However, in the face of malfunctioning domestic financial markets, local or international patents might not be of great help, and venture capital is geographically rooted (Florida and Smith, 1993). Geographic proximity is important to mitigate uncertainty and capital flows occur through the network structure of the venture capital industry rather than through the operation of free markets.

4.7 Assessment: Traditional roles of IPRs

The theory on IPRs balances the static, monopoly costs due to the temporary monopoly awarded to the patentee against the dynamic gains from increased incentives for innovation. Theoretically, IPRs are justified since, in their absence, innovation would not take place because of lack of appropriability of the returns associated with it, or inventors would – if they could – keep their inventions secret, which could then restrain information flows and hence slow down innovation.

A review of the empirical evidence shows that patent applications are not an important source of external information for most innovating firms. The exception is Japan: institutional and cultural characteristics make intra-industry spillovers important. Furthermore, there is evidence that firms use other mechanisms to appropriate returns to R&D, and that these mechanisms would be more effective than patents. Empirical evidence is mixed on the role of stronger IPRs on innovation, and econometric analyses examining the situation suffer from different flaws that make relying on their results difficult. The measurement of domestic IP protection levels is problematic.

Indices generally relate to the law as it is on paper and neglect the enforcement of the rights. The strength of IP protection is often correlated with other variables, such as openness to trade, the quality of local institutions, the levels of economic and technological development of a country, and this multicollinearity makes the assessment of the impact difficult. It is also clear that the impact of IP protection varies across industries and types of countries, hence cross-country and country level analyses might capture an average impact of IPRs. Finally, the type of data and models used are also critical.

In general, little empirical evidence exists on LDCs, where no surveys on reasons for patenting have been conducted so far. Existing studies mainly concentrate on the plant breeding industry, which might not give a representative picture. A few studies investigating the introduction of plant variety protection (PVP)[23] do not find evidence of increased breeding activity (Jaffe and van Wijk, 1995; Kesan and Gallo, 2005; Léger, 2005; Srinivasan, 2001; Tripp et al., 2006). The authors mainly relate it to the low quality of the local legal systems and hence the weak enforcement of the rights. However, the advent of PVP did not lead to an increase in private wheat breeding activity in Great Britain and in the US (Alston, and Venner, 2002; Rangnekar, 2000; Venner, 1997). Earlier studies conclude that for some crops (soybean and cereals) PVP has positively affected private research investments in the US (Butler and Marion, 1985; Perrin et al., 1983). However, the authors fail to establish a causal link between the increased rate of investment and the enactment of the legislation, and other factors could have been more influential. Hence it could be, as Venner (1997) concludes, that PVP does not provide strong incentives for innovation but is rather a marketing tool, protecting a firm's operations. He finds that an increased share of wheat was sown to private (PVP-protected) varieties while investments in R&D and yields stayed stable.

Given developing country characteristics (see section 2) the traditional roles of IPRs are likely to be even less important for them than for industrialized countries. In fact, weak domestic IPRs contributed to the economic development of the Asian Tigers (Kumar, 2002; Lee, 2000). Similarly, in the Indian pharmaceutical and chemical industries, the possibility to patent only processes and not products fostered the estab-

[23] Plant breeders' rights grant rights to exclude others from producing or commercializing materials of a plant variety. To qualify for protection a variety must be novel, distinct from existing varieties, uniform, and stable (UPOV, 1991). Two exceptional uses of protected varieties can be allowed: protected materials can be used for further breeding, and farmers have the privilege to save and replant seeds.

lishment of R&D entities to develop alternative processes to produce known compounds (Kumar and Saqib, 1996). Moreover, most currently industrialized countries (e.g. The Netherlands, Switzerland) developed under regimes of weak IP protection, and only strengthened IPRs once they had attained a certain level of technological development (Khan, 2002; Lerner, 2002). Domestic patenting is often not important because the size of the market would not provide sufficient incentives for innovation, but through their internationalization strategy, Asian countries started patenting their inventions abroad (Dodgson, 2000). Therefore though the IP protection awarded by the domestic patent system was low, the availability of strong IPRs abroad helped them expand their operations.

The quality of the domestic legal system directly affects the enforcement of the rights, hence, the appropriability of the returns to innovation, which is likely to be even lower than in industrialized countries. Another aspect relates to the costs involved in obtaining protection: information, certification and monitoring costs might be high enough to hamper the incentive effect (Koo et al., 2006; Léger, 2005). Similarly, the high enforcement costs associated to patent protection would explain the low effectiveness of patents in providing incentives for innovation in industrialized countries (Lanjouw and Schankerman, 2001).

Hence looking only at the traditional functions of IPRs, one can conclude that they fail to fulfill their role and that strong IPRs might actually hinder rather than support economic development in LDCs. However, evidence points to other roles of IPRs: how do these affect innovation?

4.8 Assessment: New functions of IPRs

Table 1 compares the reasons for patenting identified in the different surveys. IPRs define information and allow it to be exchanged or traded. This is imperative given the increasing complexity of technologies and hence the growing importance of collaborative research projects. This function of IPRs is instrumental for innovation, be it in developing or in industrialized countries, and might be even more important for LDCs, which are usually dependent on industrialized countries for the supply of new technologies (Aubert, 2005). Patents on inventions can also be used to block competitors, prevent infringement suits or help negotiations with potential partners. These aspects seem to be growing in importance and can have both negative and positive

impacts on innovation, depending on the situation, but the extent to which they prevail in LDCs has not been investigated. As the quality of the domestic legal system is usually poor, the enforcement is not likely to lead to effective blockades. Regarding the role of patents for cross-licensing activities, they might support innovation by reducing the transaction costs of accessing important patented technologies, but it depends on the relationship (substitutability or complementarity) between the patents.

Given the relatively lower level of technological development, developing country patents might not be very attractive bargaining chips for international R&D collaborations[24]. Foreign companies might be more interested in the traditional knowledge or genetic resources of a country. These issues are discussed in more detail in section 5.3.

Table 1 **Reasons to patent in different empirical studies**

	Arundel et al 1995 (EU)	Duguet and Kabla 1998 (France)	Cohen et al 2000[a] (USA)	Pitkethly 2001 (Japan)	Cohen et al 2002 (Japan)	Blind et al 2006[b] (Germany)
Traditional roles						
Protection from imitation (+)	1	1	1	1	1	1
New roles						
Blocking (defensive) (+/-)	3	2	3	-	3	3
Blocking (offensive) (+/-)	-	-	2	2	2	5
Negotiation power (+/-)	2	2	4	3	4	8, 10[c]
Reputation (collaboration) (+)	-	-	5	-	5	4, 9[d]
Access international markets (+)	5	5	-	-	-	2[e], 6[f]
Securing national markets (+)	-	-	-	-	-	3
Performance measure (0)	6	6	7	-	7	12
Licensing revenues (+)	4	4	6	4	6	13
Increase company's value (+)	-	-	-	-	-	7, 11[g]

Source: Author's compilation. Notes: a: results for process innovations; b: other possible reasons (rank in parenthesis): influence on standardization (14). c: assets for exchange; d: incentives for employees; e: securing other European markets; f: securing non-European markets; g: access to the capital market

The role of IP protection in helping to access foreign markets through exports, investments and licensing activities is mainly positive for industrialized countries, and IP protection has different impacts dependent upon the initial conditions characteriz-

ing the host country and the type of activity taking place. The evidence on LDCs is contradictory and strongly related to the size of the country, the type of industry, and the initial level of development. In several cases, the level of IP protection could also capture other characteristics of the country such as its level of technological development or the quality of its institutions. This is discussed in section 5.2.

Finally, IPRs are important to signal expertise, to investors as well as potential research collaborators. Valuing intangible assets is difficult and IPRs are especially important for small, R&D-intensive firms to signal their quality. There is no evidence on these aspects for developing country firms and theoretically, patents could be important in international collaborative R&D projects or for firms wishing to obtain capital on international markets. However, in practice venture capital has a very local character and might not be available for firms in LDCs.

It is difficult to assess the aggregate effect of all the functions patents fulfill: table 2 presents an attempt to do so. Though the case for the traditional functions of patents – supporting diffusion, ensuring appropriation of returns from innovation, and providing incentives for innovation – is rather weak, the complementary functions patents perform probably lead to a positive overall effect. However, patents are not likely to overcome the serious problems plaguing innovation in these countries: low levels of technological capacities, imperfect markets for technology, risk and capital, high transaction costs and weak legal systems. Hence, patents are not a sufficient condition to support innovation in a country, yet the past development processes of now industrialized countries show that patents might not be necessary either.

On top of potentially slowing down competitors' innovation, strategic uses of patents increase the number of transactions necessary to perform innovation, which translates into increased costs. Search, licensing and monitoring costs rise, driving up the cost of innovation without increasing benefits to society in terms of additional innovation or social welfare. This represents a diversion of resources from innovation towards relatively unproductive, administrative uses.

[24] Here again, a difference must be made between advanced, emerging countries such as Brazil and China, and other, least-developed countries.

Table 2 **Functions of patents and their impacts on innovation**

	DC patent holder	DC incumbent	LDC patent holder	LDC incumbent
Diffusion	-	0	-	0
Appropriability	+/0	N/A	+/0	N/A
Incentives for innovation	+/0	+/0	+/0	0
Technology transfer	+	+	+	+
Strategic uses				
Blocking competition	+	-	(+)	(-)
Cross-licensing	+/-	+/-	(+/-)	(+/-)
Secure investments	+	N/A	(+)	N/A
Signaling	+	N/A	(+/0)	N/A
	Industrialized countries		**Developing countries**	
Trade	+/0		+/0	
FDI	+/-		?	

Source: Author's compilation.

Note: symbols in parenthesis are expected impacts (no evidence exists on these aspects)

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5 Implications for LDCs

5.1 IPRs, spillovers and local innovation

The evidence reviewed supports the view that domestic IP protection levels affect the decision to license a technology or invest in a country. Technology spillovers can result from these and other channels, such as capital good imports and trade in general. These contributions to local innovative activity can be important but the domestic level of absorptive capacity needs to be taken into account. Deolalikar and Evenson (1989) find that the flow of international technology stimulates Indian invention, and several studies find that both domestic and trade partners' levels of technological development have important effects on host country productivity (Coe and Helpman, 1995; Coe et al., 1997; Connolly, 2003; Keller, 2001).

However, evidence on spillovers from FDI at the industry and firms levels is not as conclusive. Case studies of different countries (Germidis, 1977) show almost no evidence of technology spillovers to local companies. Econometric evidence at the firm level from Venezuela (Aitken and Harrison, 1999) shows a positive relationship between foreign firm participation and plant productivity. However, local firms' productivity actually decreases with an increase in the level of FDI, which the authors attribute to a market-stealing effect. The authors find no evidence of technological spillovers from foreign to local firms, a conclusion that also holds for the Moroccan manufacturing industry (Haddad and Harrison, 1993).

Conversely, evidence for the textile industry shows that foreign investments did support the development of the local industry in Bangladesh (Rhee, 1990). Javorcik

(2004b) also finds positive intra-industry spillovers in Lithuania, but only for projects with mixed (local and foreign) ownership. The contribution to local innovation hence depends not only on the level of absorptive capacity in the host country, but also on the type of FDI taking place. Recent evidence on China (Wang and Yu, 2007) shows that the benefits from MNC's spillovers to locally owned enterprises are higher when the foreign presence is lower and follow an inverse u-shaped pattern. Moderate levels of foreign presence are most beneficial to the performance of Chinese locally owned firms, and the level depends on the characteristics of the industry.

Domestic IP protection should also provide incentives for domestic innovation. However, the limited effective demand in LDCs represents an obstacle to the performance of innovation, since the local market for an invention is often not large enough to allow the inventor to recoup his research investment. Conversely, the domestic patent system becomes irrelevant if the innovator chooses to patent abroad to take advantage of export markets.

Other problems arise for scientific and technological innovations. A patent can be granted only if the invention is new and non-obvious, which often implies that the innovation takes place at the technology frontier. However, given the lower level of technological development in several LDCs, a significant proportion of local innovations might not qualify for protection, and hence patents might not be an appropriate tool to stimulate local innovative activity. Given the national treatment clause of the TRIPs agreement (Art. 3) countries cannot differentiate between local and foreign applications hence local inventors face the technological levels set by their industrialized country counterparts. The cost of protection must also be taken into account. In certain countries, it might be higher than the potential benefits expected from the introduction of the innovation, rendering protection irrelevant (Léger, 2005).

Patent protection theoretically severely restricts the possibility to reverse-engineer or imitate a product or process, important learning strategies in LDCs (Kumar, 2002; Lall, 2003). These learning-by-doing processes contribute to the development of tacit knowledge (Nelson and Winter, 2002) that is instrumental for the absorption and use of inter-firm spillovers (Ruttan, 2001), hence the strict enforcement of patents could reduce the development of domestic technological capabilities in LDCs (Kim, 2004). No empirical evidence has been found on this aspect.

5.2 IPRs, technology transfer and appropriate technologies

Theoretically, assuming different preferences between the North (industrialized countries) and the South (LDCs), stronger IP protection in the South would provide incentives for the performance R&D in the North addressing southern needs (Diwan and Rodrik, 1991). However, anecdotical evidence (e.g. essential medicines for AIDS and orphan diseases) shows that strong IPRs might not be a sufficient condition for the performance of R&D, and empirical evidence on this subject points to the same conclusion (Lanjouw and Cockburn, 2001). In fact, other factors, such as input costs, resource availability and especially market size appear to be a lot more important in that respect (Park and Lippoldt, 2003). Indeed, the effective demand is fairly small in most LDCs; hence the returns to innovation could be smaller than the development costs. Of course, small countries (e.g., Taiwan, Finland) can export to overcome this handicap, depending on the type of innovation, but then the domestic patent system does not matter as much as patent systems in the export markets.

As was already mentioned, strong IPRs affect the decision to transfer technology, and the type of technology being transferred. Facing weak IPRs, firms in the pharmaceutical and chemical industries would be likely not to license or transfer an invention, while firms in other industries would license/ transfer an older technology. Though in India foreign technology purchases was found to be complementary to domestic innovative activity (Deolalikar and Evenson, 1989), the general wisdom is that given the lower levels of absorptive capacity and tacit knowledge, developing country innovation might benefit more from the transfer of more mature technologies, where patent protection is likely to be expired, rather than products or processes at the technology frontier, that would benefit a minority of firms or research organizations operating at the technology frontier (Ruttan, 2001). Indeed, the duality of these economies implies that such transfer could benefit MNEs and advanced research institutes in LDCs without spilling over to the rest of the economy. The average small and medium enterprise is more likely to benefit from using and adapting mature technologies. The potential for spillovers among firms at similar technological levels is also higher (Tirole, 1993).

Since technological developments are induced by economic forces and local characteristics and endowments (Hayami and Ruttan, 1985), firms in industrialized countries often privilege the development of labor-saving technologies. These are often not adequate for LDCs, where, given the generally abundant supply of labor and rela-

tively lower availability of capital, labor-intensive or capital-saving technological change would be more appropriate. For certain technologies, e.g., plant varieties, agro-ecological conditions make transfers hazardous; hence most countries conduct agricultural R&D, if not to innovate at least to adapt foreign innovations to local conditions. Still, if appropriate technologies are being transferred, monopoly pricing of the (patented) products and processes prevails. Compared to a situation without IPRs (i.e., competitive pricing rather than monopoly pricing of a technology) consumers in LDCs face higher prices, and the monopoly rents are transferred from (mostly) poor consumers in LDCs to richer entrepreneurs in industrialized countries, which raises equity concerns. When taking the different marginal utilities of income into account, the case for equity is even stronger. Yet given their small aggregate purchasing power, these monopoly rents are likely to contribute only marginally to the inventor's benefits – and incentives. It is however important to keep in mind the increase in social welfare that the introduction of an innovation entails.

Overall, strong IPRs do not appear to provide incentives for the conduct of northern R&D addressing southern needs. The impact of IP protection on LDCs however depends on the level of technological development, but also the size of the market – large, more technologically advanced LDCs are likely to benefit from IP protection in the long run, but least-developed countries face higher costs without deriving benefits (Mashelkar, 2001). Under the current situation of generally low levels of absorptive capacity and tacit knowledge, FDI and technology transfer from industrialized countries create limited spillovers to host economies. Actually, stronger IPRs existing under the current international architecture are likely to hamper the development of local technological capabilities by impeding the imitation and reverse-engineering of patented products, without providing strong incentives for local innovation.

5.3 Traditional knowledge and alternatives to IPRs

As mentioned in section 4.2, LDCs might not have many patents to offer as bargaining chips. However, potential partners might be more interested in the local traditional knowledge[25] and genetic resources[26] that countries possess. These assets are often

[25] Traditional knowledge is defined as a traditional technical know-how, or ecological, scientific or medical knowledge, encompassing the content or substance of traditional know-how, innovations, informa-

specific to a region or country, and hence can give their owner bargaining power in negotiations with potential partners.[27] However, traditional knowledge must be defined in order to be traded and finding the most appropriate way to do so is still a challenging question (see UNU-IAS, 2004). Several cases of patents granted to firms or individuals from industrialized countries on aspects of traditional knowledge from LDCs have occurred lately,[28] increasing the pressure for the establishment of defensive mechanisms against such "biopiracy". Visser (2004) estimates that LDCs lose approximately $5 billion in royalties annually from unauthorized use of traditional knowledge.

Alternatives to patents exist: utility models were instrumental in supporting innovation in Germany and East Asian countries (CIPR, 2002; Suthersanen, 2006). Novelty instead of inventiveness is required for protection, the "inventions" are registered rather than examined, and the protection granted is shorter than for patent protection. Such a system favors the diffusion and absorption of technology and stimulates incremental innovation, and in Japan, utility models were more important than examined patents for increasing productivity (Maskus and McDaniel, 1999). Utility patents are not mentioned in the TRIPs agreement; hence countries could customize the system to their needs. A similar system would be one based on liability rules (Reichman, 2000), the difference being that automatic licenses would be granted, hence eliminating the eventuality of strategic behavior and keeping transactions (and transaction costs) at a minimum. These two systems would however not tell anything about the quality of the invention, while the examination process leading to the grant of a patent theoretically produces a "quality certification" externality.[29] However, the lack of quality control could also lead to an inflation of products and processes, for strategic

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tion, practices, skills and learning of systems such as traditional agricultural, environmental or medicinal knowledge (WIPO, 2005)

[26] Traditional varieties or plants found in nature do not qualify for PBR protection in most countries – varieties must be stable, uniform and distinct (new).

[27] See Greene (2004) for a discussion on the difficulties involved in the field of research on traditional knowledge.

[28] For example, patents have been granted on the use of turmeric in wound healing, and on the appetite-suppressing elements of the Hoodia cactus. These cases touch upon commonly held knowledge in India and southern Africa, respectively.

[29] However, critiques of the American patent system claim that the USPTO resembles more and more a registration system (Aharonian, 2000) resulting in the grant of questionable patents, and that patent litigation cannot be relied upon to reliably fix these errors (Farrell and Merges, 2004). See also Shapiro (2004) and FTC (2003).

purposes, which could increase search costs for interested users, and the reputation function of patents would not have the same importance in such systems.

6 Conclusion and Areas for further research

This paper systematically reviews the empirical evidence on IPRs to assess the impact of their changing roles on innovation in LDCs. It finds that patents do not provide strong incentives for innovation, but that their new, complementary roles – definition for technology transfer, strategic uses, securing access to markets, and signaling reputation – are important for innovation in industrialized countries. Very little empirical evidence exists in general for LDCs and even less for these new functions but, taking into account developing country characteristics, patents are even less likely to support innovation there.

Some of the new functions (e.g. signaling, definition) might be more important in LDCs given malfunctioning or non-existent markets for financial capital and insurance against risk, and technology transfer. The evidence gathered here shows that stronger IPRs are not likely to support local innovation, and that IPRs would support technology transfer from industrialized to LDCs but that the technology transferred might not be appropriate for the local conditions and priorities. Finally, utility models, as an alternative to strong patents, have played an important role in the technological and economic development in emerging economies. This evidence points to the need to reassess the costs and benefits of the patent system taking their new roles – and the associated costs and benefits – into account. The justification of IPRs being the promotion of innovation, the impact of these new functions on innovation has to be investigated.

Another issue worth considering concerns the relevance of domestic patent systems. Given the generally low quality of developing country domestic legal systems, the enforcement of domestic patents is problematic. Furthermore, important innovations will be patented abroad, in large markets such as the US or Europe, since effective demand in domestic markets is usually low. Finally, several of the other functions of patents (e.g., signaling, definition) do not really depend on the origin of the patent, but rather on its quality, where once again US or European patents are more recognized.

Therefore, and given the high costs involved in setting up and operating patent offices in LDcs, their relevance needs to be reconsidered.

From a policy perspective, given the poor performance of IPRs for supporting innovation, alternative or complementary methods allowing to better tailor IP systems to the domestic situation should be considered. In general, emphasis should be put on the diffusion of new information to foster technological development: mechanisms to appropriate returns to innovation exist and are much more effective than patents in this respect. For small LDCs, the domestic market often does not provide strong incentives for innovation, hence export markets play a much more important role for them. Accordingly, domestic IP systems do not really matter for these innovations, apart from their role in limiting imitation locally, which, given the evidence available on the quality of the legal systems in place, might not grant an effective protection. In general, more evidence is needed on the role of domestic IP systems for local innovation.

Given that the propensity to patent increased in the last decade without reflecting an increase in the intensity or efficiency of R&D, a reassessment of the relevance of patent applications or grants as a proxy for innovation in economic analyses needs to be effectuated. Similarly, the use of patents to attract financing or partners in R&D collaborations might be misleading in a situation where patents do not reflect innovative capabilities.

In general, more empirical research needs to be focused on LDCs: surveys and other empirical studies investigating the reasons for patenting in these countries, assessments of the performance of IP systems, appraisal of the new functions of IPRs are all needed to better understand, ideally at the firm and industry levels, the reasons why IPRs might have different impacts on innovation, as illustrated by macro studies.

Finally, the evidence analyzed here shows that LDCs should cooperate to change the trend towards the strengthening of IP protection through multilateral and bilateral agreements, especially as the pressure rises with the discussions concerning the substantive patent law treaty, and pursue their efforts through WIPO’s development agenda to increase the benefits LDCs can derive from IPRs.

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