INNOVATION AND APPROPRIABILITY, EMPIRICAL EVIDENCE AND RESEARCH AGENDA

ANDRÉS LÓPEZ*

1. INTRODUCTION

Intellectual property rights (IPRs) have attracted increasing attention both in academic circles as well as in public policy debates over the past decades. This has gone hand-in-hand with their increasing use, particularly (but not only) patents, reforms in the national and international legal frameworks that have resulted in the strengthening of IPRs and the fast growth of sectors in which knowledge, innovation and appropriability play a key role (e.g. biotechnology, information and communication technologies and the cultural industries). Intense debates among researchers have taken place on a wide range of issues, including the reasons for the growing use of IPRs; the impact of the strengthening of IPRs on innovation; the role of IPRs in developing countries; whether there is a need for international harmonization of the laws regulating the matter and the consequences of IPR legislative reforms on poor communities in areas such as health or traditional knowledge.

This paper aims at exploring one of the main areas to which research efforts have been devoted, namely, the determinants of the use of different appropriability strategies at the firm and sectoral level. The origins of the empirical literature on the subject can be traced back to the seminal works on patents by Scherer *et al* (1959) and Mansfield *et al* (1981). However, a key turning point took place in the mid-1980s when Teece (1986) established a new theoretical framework for analyzing the relation between innovation and appropriability and Levin *et al* (1987) studied how firms used a variety of different appropriability strategies including, but not limited to, patents.

In the following years, research on the subject was spurred by the upsurge in patent applications, reforms in IPR legislation and the availability of innovation surveys with data on innovation at the firm level that allowed economists to apply more sophisticated research techniques. However, while there are some facts that have been more or less clearly demonstrated by the available empirical evidence, there are also many areas and subjects where disagreement or, more frequently, uncertainty prevails. This is particularly the case in non-manufacturing sectors as well as in developing countries, where very few studies on the subject have been undertaken.

More theory and more solid empirical evidence, including the development of new databases specifically aimed at inquiring about the use of IPRs and other appropriability mechanisms, would be needed, in order to achieve significant advances in our knowledge about the dynamics of innovation and appropriability in different countries, sectors and type of firms.

This paper reviews the empirical literature[1] on the use of appropriability strategies,[2] including the determinants of the propensity to patent, with a view to highlighting the main findings. It analyzes the strengths and weaknesses of the research that has been carried out so far on the subject and suggests a research agenda both for developed as well as for developing countries.

* Principal Researcher, CENIT and Professor, Department of Economics, University of Buenos Aires, Buenos Aires, Argentina. Director of the Centro de Investigaciones para la Transformación (CENIT). The able assistance of Natalia Gajst is gratefully acknowledged. The views expressed in this paper are those of the author and do not necessarily represent those of WIPO.

Therefore, section 2 of the paper briefly presents a conceptual framework for organizing the discussion. In section 3 the available empirical evidence on the subject is surveyed. Section 4 summarizes the findings and analyzes the strengths, weaknesses and limitations of the empirical literature and section 5 suggests a research agenda, to address some of the research gaps and broaden our understanding of the issue, particularly in developing countries and countries with economies in transition.

Before proceeding with the paper, it is useful to note that it will not analyze the impact of patenting and other appropriability tools on variables such as profits or innovation activities. While part of the literature surveyed here considers these issues, this is not the focus of this paper. In the same vein, it is not going to discuss whether some appropriability mechanism is "better" than others at the firm or at the more general "social" level. Although these are clearly very relevant questions, their analysis falls beyond the reach of this paper.

2. INNOVATION AND APPROPRIABILITY: A BRIEF CONCEPTUAL FRAMEWORK

There is widespread agreement that in a perfect competition setting, that is, a situation in which, among other assumptions, no producer has market power, there is no product differentiation and all firms have immediate and perfect access to the same technologies, the rate of innovation in a market economy would be very low.

The problem was first stated in the early 19th century by Jeremy Bentham in his Manual of Political Economy and was later forcefully argued by Joseph Schumpeter (1942). Both stressed the need for entrepreneurs to expect supernormal profits by enjoying some kind of monopolistic power over their inventions. That expectation would encourage them to devote time and money to innovation activities.

As was highlighted in the seminal papers by Nelson (1959) and Arrow (1962), the main problem is one of appropriability and relates to the semi-public good characteristics of knowledge, for which exclusion is feasible but rarely or never perfect. If inventors or innovators could not rely on some means to protect the knowledge they create, they would be at a disadvantage *vis à vis* rivals who did not incur the often very high fixed costs of creating that knowledge. Such rivals would presumably be able to imitate it at a much lower cost or, in extreme cases, at zero cost.

As appropriability of knowledge is always incomplete, externalities arise, creating a difference between the private and the social marginal return of any new knowledge being generated, which could lead, under perfect competition, to under-investment in innovation activities. Furthermore, knowledge creation is affected by other market failures, since it is an activity that is subject to high levels of uncertainty and strong indivisibilities.

Hence, some kind of incentive is needed to spur private agents to devote resources to innovation activities. As stated above, one possible answer to this dilemma was provided by Schumpeter (1942), who argued that the promise of a (temporary) "monopoly power" was needed. However, as many authors have stressed, that is not the only possible answer. For instance, prizes or procurement (e.g. government-funded research) are alternative incentive schemes that are used in many situations and whose use could be further expanded (see Gallini and Scotchmer (2002)).

This paper, however, focuses on appropriability, i.e. the different means an economic agent may use to profit from its inventions or innovations by temporarily enjoying some kind of monopo-

listic power over the knowledge it creates. Brief mention will also be made of other strategies that are available to firms nowadays and that could allow them to reap more profits by sharing (rather than appropriating) the knowledge they create. This means that imitation may not always be harmful, since compatibility and network effects may also provide a source of profits (Hurmelinna and Puumalainen (2005)).

IPRs, including patents, copyright, trademarks, industrial designs, utility models[3] and plant breeders' rights,[4] are some of the appropriability mechanisms that may be used by innovators. However, as is well known, there are other available mechanisms, including the exploitation of lead time, moving rapidly down the learning curve, the use of complementary manufacturing capabilities and secrecy (see Cohen *et al* (2000)). Since labor mobility is also a form of technology imitation, labor legislation, contracts and human resource management practices are also very relevant appropriability mechanisms (Hurmelinna and Puumalainen (2007)), although some of those mechanisms could be included under the heading of secrecy. There are also a number of practical and technical means of protection, such as passwords, digital signatures, copy prevention mechanisms, etc. which are used in some industries.

The logic behind the variety of mechanisms employed by firms to protect their innovations can be understood in the light of the work by Teece (1986), who argued that profits from innovation depend upon the interaction of three groups of factors: appropriability regimes, complementary assets and the presence or absence of a dominant paradigm in the sector in which firms operate.

According to Teece, appropriability regimes are basically characterized by the nature of the technology and the efficacy of the available legal mechanisms for protection. Tight or loose appropriability regimes are defined by the capability of firms to retain greater or smaller profits from their innovations. Some technologies can be protected as trade secrets (this is often more feasible with process innovations than with products). Patents, in turn, are specially suited for inventions such as new chemical products and many mechanical inventions. The nature of the knowledge involved is also relevant. While codified knowledge is more easily replicable, tacit knowledge[5] is harder to articulate and transfer, since it is implicit and idiosyncratic and is often embedded in firms' routines and capabilities. Tacitness is in itself an appropriability mechanism for knowledge holders, but it is still subject to imitation – for instance, through hiring individuals/employees who have critically-important skills (Hurmelinna and Puumalainen (2007)).

The concept of complementary assets is a very relevant one since it highlights the fact that the successful commercialization of an innovation requires manufacturing, marketing and after-sales capabilities, among other factors. This means that appropriability cannot be entirely dependant on the more or less successful features of the technology to be protected, but is heavily based on the firms' other capabilities.

In turn, the dominant paradigm or dominant design theory (Abernathy and Utterback, 1975) suggests that in many industries there is a cycle that goes from a first pre-paradigmatic stage, in which firms compete through different designs in order to win pre-eminence in the market, to a second stage in which competition is more based on price, with economies of scale, learning and specialized equipment being more relevant. The nature of innovations and the type of appropriability mechanisms employed change during this trajectory. Hence, the means firms use to protect their innovations are also dependant on the stage in the life-cycle of the industry in which they operate (Dosi *et al* (2006)).

In light of the above, it comes as no surprise that innovating firms differ in the mechanisms they use to protect the knowledge they create, being those differences mainly related to firms' spe-

cific factors (such as size, capability or innovation strategies), knowledge-specific factors (tacit vs. codified), technology-specific factors (e.g. product vs. process innovations) and industry-specific factors (e.g. life-cycle stages and appropriability regimes). The country's legal environment is obviously another relevant factor, since it defines what can or cannot be protected through different legal mechanisms (and the level of effective enforcement of those mechanisms).

Moreover, the different appropriability mechanisms interact with each other in various ways. For instance, some mechanisms may be thought of as pre-requisites, derivative or supportive of other forms of protection. For example, technical means may be a requisite for keeping a trade secret. Patents or secrecy may help create lead-time advantages (Hurmelinna and Puumalainen (2007)). Different mechanisms may also be employed at the various stages of the innovation process. For instance, firms may initially rely upon secrecy prior to the commercialization of a new product, and later on apply for a patent and/or display aggressive marketing and lead-time strategies. In turn, lead time may be used to achieve advantages in manufacturing (moving along the learning curve and gaining economies of scale) and marketing (building up marketing sales and service capabilities), and to delay imitation by competitors (Harabi (1995)). Furthermore, more than one mechanism may even be employed at the same time for a given innovation when it comprises separately protectable components or features (Cohen *et al* (2000)), or when legislation allows for a "piling up" of IPRs over the same invention. Finally, the effectiveness of the different mechanisms varies over time; trade secrets may be revealed, patents expire and may be invented around, but trademarks, for instance, may increase their value dramatically and be renewed indefinitely (Hurmelinna and Puumalainen (2005)).

In this complex scenario, we cannot always make straightforward predictions regarding the relations between some firms, industries and technology features and the use of different appropriability methods. For instance, as stated by Arundel (2001), at the theoretical level, there are reasons to expect that small firms could find patents more valuable than large firms, but there are also arguments that could lead us to expect the opposite. While small firms could use patents to create a temporary barrier against competitors in order to build the manufacturing and marketing capabilities needed to become a successful innovator, it could also be that patent application costs and the costs of protecting patents from infringement could lead them to value secrecy more than patents. Furthermore, small firms could have fewer patentable innovations than large firms, since they could be mostly engaged in incremental improvements. Large firms often have IP departments or other similar organizational devices which could also lead them to display a higher patent propensity. At the same time, as shown in Giuri *et al* (2007), since they bear relatively lower costs in terms of patent applications and litigation, it comes as no surprise to find that large firms have a very high level of unused patents compared with small and medium-sized enterprises (SMEs) and may also patent minor innovations.

The analysis of the subject is further complicated by the fact that some IPRs, especially patents, are increasingly used for ends other than appropriating the returns from innovation. Most notably, "strategic" uses of patents – e.g. patent blocking, use in negotiations, prevention of suits, etc – are increasingly common (Hall and Ziedonis (2001)). Thus, when we observe a firm applying for a patent we cannot assume that its purpose has necessarily to do with the appropriability of the results of some innovation. In other words, there may be a divorce between the effectiveness of patents as appropriability tools and their rate of use since firms may use patents in order to attain other objectives.

As the reader will probably have noticed at this point, the issues discussed so far are mainly related to the dynamics of technological change in developed countries, where the bulk of the world's knowledge is created and a large number of firms have strong innovation capabilities; hence the appropriability issues are more acute.

What happens when trying to translate this debate to the reality of developing countries? First, it must be emphasized that the term "developing countries" comprises a wide variety of nations that are at very different stages of economic development and have very heterogeneous levels of technological capabilities. Hence, the innovation-appropriability dynamics will be very different, for instance, in advanced developing countries such as some Latin American or Asian economies where industrial, export and innovation capabilities are more or less strong, *vis à vis* most least developed countries (LDCs), which rely on traditional agricultural activities and have poorer productive and technological capabilities.

Second, it is often thought that developing countries are mainly imitators or adopters of technologies and knowledge developed elsewhere. Hence, the debate on IPRs in developing countries is often focused on whether lax or strong IPRs are more favorable for technological change in those countries. While lax IPRs are thought to favor imitation, copy and reverse engineering – and hence are seen by some authors as a favorable factor for the deployment of learning processes that could lead in the medium and long run to the creation of genuine innovation capabilities in those countries – it is often stated that strong IPRs are a condition for developing countries to receive updated technology transfers by means of licenses and foreign direct investment.

Although this is a crucial debate, it is often conducted at a mainly theoretical level, or on the basis of aggregate evidence (e.g. trying to relate foreign direct investment (FDI) flows with IPR legislation strength) or using anecdotal information. Micro-level studies are, on the contrary, relatively scarce, making it difficult to learn about the determinants of the use of IPRs in different types of firms and sectors in developing countries. In other words, very little is known about the appropriability strategies displayed by different groups of firms, or the ways in which different kinds of innovations are protected in these countries. Furthermore, there is a lack of sound evidence regarding the perception of domestic firms in developing countries about the role that IPRs play, or might play, in the context of their innovation strategies.

The question is that, contrary to the assumption mentioned above, although developing countries are in fact mostly dependant on foreign technology sources, domestic innovative activities also exist. *Strictu sensu*, as suggested above, even copying and making reverse engineering imply some kind of innovation efforts. However, innovation activities, at least in more advanced developing countries, go well beyond copying, as is clearly demonstrated by the available evidence that shows the existence of a wide range of technological capabilities in those countries, from the more widespread adaptive and incremental ones, to the rarer but far from negligible "genuine" innovative capabilities. The evolutionary trajectory of some East Asian countries such as the Republic of Korea, illustrates how economies that begin copying and adapting foreign technologies may gradually generate endogenous innovation capabilities as their firms progressively become world-class innovators.

The fact is that the relation between competition patterns, productive structures and innovation in developing countries is very different from that in developed countries, and hence we should also expect to find differences in the pattern of use of IPRs and other appropriability mechanisms (differences should also be found when comparing developing countries which are at different stages of industrial and technological development). Unfortunately, we often lack the theoretical tools to make clear predictions about the shape of these dynamics.

However, some very general arguments could be made. First, we could expect that the relevance of all (or most) appropriability mechanisms increases as the development process proceeds. Second, if SMEs are generally at a disadvantage for using some kind of IPRs (most notably patents), this trend could be even more pronounced in the case of developing countries, where SMEs are often weaker than their counterparts in the developed world.

Third, as frontier or world-first innovations are rare, it could be the case that, when they are allowed by the legislation, domestic firms could consider utility models more valuable than patents – which could be better suited for transnational corporation (TNC) affiliates that revalidate patents obtained in other countries. At the same time, the use of trademarks could be even more relevant than in developed countries as firms compete more through product differentiation than via continuous innovation.

Fourth, in many developing countries there is a widespread presence of TNC affiliates, and these affiliates often account for the bulk of the use of registrable appropriability mechanisms such as patents. Hence, there is a need to pay more attention to the influence of capital ownership on patenting decisions than is usually the case in studies undertaken in developed countries.

Finally, another relevant issue, which is also present in some developed countries, is related to the fact that for many firms in developing countries it is perhaps more relevant to patent abroad than to patent in their own countries (since the most interesting markets are those of developed countries, for instance).[6] The factors that influence the decision on where to patent, therefore, need to be carefully studied.

3. THE EMPIRICAL EVIDENCE

3.1 Some Introductory Remarks

When analyzing the available studies on innovation and appropriability it is important to distinguish them according to their scope, methodology and objectives. The studies reviewed for this survey have different aims and try to answer different questions. Furthermore, employed methodologies also vary; for instance, while there are many studies that employ econometric techniques, others are based on case studies or descriptive statistical analysis. The same goes for the type and number of firms included in each study, the number of years covered, the richness of the databases, etc.

In this regard, note must be taken of the fact that this paper surveys studies and papers that have different publication status – i.e. papers published in refereed journals, working papers, books, reports, etc. Although it could be argued that a review of the empirical literature should be restricted to studies that have been subject to referral procedures, we have adopted a more flexible approach, especially considering the fact that the body of literature on these issues is not as large as one would wish.

Economists prefer studies based on the use of econometric techniques (which are often the only accepted empirical method in most academic journals in the field of economics), since they allow for a greater methodological rigor. Economists assume that they can rely more on the true existence of relationships between different variables when they are found to be statistically significant through econometric tests than when they are merely the result of the observation of descriptive statistical tables. Furthermore, econometric methods allow us to estimate the amount of the effect that a change in a certain variable has on the variable of interest for the analysis (for instance, how much the propensity to patent increases when the size of a firm increases by 1 per cent) –these are the so-called marginal effects.

However, the use of econometric techniques also has problems. For instance, it is often the case that databases used for econometric studies were collected for purposes other than those pursued by the researcher engaged in those studies. Hence, the researcher must adapt his/her analysis to the existing data, which are not always the ones that he/she would need for a proper testing of the hypothesis he/she wants to confront.

Econometric methods are, on the other hand, heterogeneous regarding their strengths and weaknesses. In fact, econometric techniques have been subject to changing approaches in terms of those which are deemed as adequate or not over time. It is not always the case that the researcher is able to use the strongest or the more appropriate econometric technique since he/she is often dependant on the information contained in the database that is available to him/her at the moment the research is undertaken. Although this paper is not devoted to highlight the strengths and weaknesses of the econometric method used in the surveyed literature – notwithstanding the fact that in some specific cases mention will be made in that regard – the reader should be aware of the fact that not all those methods have the same properties and/or are equivalent in their robustness.

Furthermore, while econometric studies allow us to go beyond anecdotal evidence and avoid drawing false inferences based on the observation of apparent statistical associations between different variables, case studies can contribute with very relevant details about the decision of a firm to use different appropriability mechanisms. In this regard, case studies could, for instance, allow us to follow the decision-making process that leads a firm to use one or more appropriability mechanisms at different moments of the innovation process. More generally, if properly and systematically conducted, case studies could shed light on qualitative aspects that are involved in the innovation and appropriability strategies used by firms.

Another dividing line in the field of the studies on appropriability mechanisms is that between those that focus on a specific mechanism – usually patents – and those that explore the variety of appropriability methods a firm can employ (secrecy, lead times, etc.). The latter often aim at learning about the preferred appropriability methods, trying to find out which method is more used and/or considered to be more effective by innovative firms.

As will be seen below, there is not necessarily a linear relationship between the effectiveness of a certain appropriability method and its rate of use. For instance, while patents are often considered an ineffective method for protecting innovations, this does not mean that firms do not use them. In fact, while there are factors that may deter firms from using patents, as mentioned before, patents allow firms to pursue objectives different from protecting their innovations (this will be developed in the next section).

A related fact is that while in the case of patents we may have an "objective" measure of their use – since we may know if a firm applied for and/or was granted a patent – this is not often the case when speaking of the so-called "strategic methods" (e.g. lead time, secrecy, etc.). That is, we may ask a firm if it considers lead time an effective protection mechanism and/or it uses lead time as an appropriability method, but databases rarely allow us to know if that firm actually used lead time for protecting a specific innovation.

Another issue that needs to be carefully considered when undertaking a survey of the empirical evidence on this area is the fact that the definitions of innovation and/or of innovative firms also differ among available studies. This is important since usually only firms that innovate need to employ appropriability mechanisms – although this is not the case for trademarks. However, it is not always clear what we mean by innovation.

The problem is that while it is relatively easy to know if a firm spends money on research and development (R&D) activities (and also how much money it spends), the same is not true when we try to learn if the firm obtained or not an innovation – an innovation that could be the result of R&D activities but also of other kinds of learning activities, or even of pure chance.[7] Unfortunately, the main group of firms of interest when studying the use of appropriability mechanisms is not composed of R&D performing firms but those firms that managed to intro-

duce a new and/or improved product or process in the economy. Measures of innovation outputs are unfortunately not without problems; while counting innovations or asking whether a firm introduced or not an innovation during a certain period often does not make much sense in economic terms. Another often-used indicator – the percentage of sales corresponding to new products – is also not unambiguous and fails to consider process innovations.

Although available surveys on this subject frequently ask firms whether they obtained an innovation during a certain period, we often do not know what kind of innovation it is – and when there are answers to this question they are subjective ones, i.e. based on the firms' own perception.[8] This is important insofar as, for instance, only innovations that meet some specific requirements –novelty, non-obviousness and utility or industrial applicability – can be patented. More generally, different kinds of innovations (and in saying this we go beyond the traditional distinction between product and process innovations) may be protected by different appropriability methods, and this issue is rarely analyzed in available studies, mostly due to the lack of appropriate information on the subject. In this regard, as stated by Hussinger (2005), a frequent drawback of firm-level studies on appropriability tools arises from the fact that firms typically have more than one invention and, furthermore, tend to bundle different tools. Hence, it is difficult to know what innovations are protected by what appropriability mechanisms.

All these differences among the studies devoted to the analysis of appropriability mechanisms lead us to be aware of the need to be careful when comparing their findings, since answers may be different because questions were different or because they used non-comparable methods.

In addition, most studies on the issue under analysis are based on the manufacturing industry. Much less is known about services or agriculture, where specific protection mechanisms are in place. In other words, the evidence about innovation and appropriability is heavily biased towards industry, giving us an incomplete picture on the subject. Furthermore, some relevant legal appropriability mechanisms, such as trademarks, protection of plant varieties and copyright, have received much less attention than patents. While this could be the result of the fact that patents are often perceived to be more "important" in economic terms than other mechanisms – although not more used, since many more firms use trademarks than patents – it is perhaps also the case that it is the result of the availability of information – a fact that reminds us that economists do not always study the more relevant issues but those for which the required information is available.

Finally, very few studies are available for developing countries. The present survey includes some of those studies, but, as is emphasized below, there is a clear need for undertaking research projects in developing countries since there is an almost total absence of rigorous evidence on the subject. The promotion of new studies on innovation and appropriability in non-manufacturing sectors and in developing countries must, however, be accompanied by efforts to adapt the kind of research questions usually posed in studies for the manufacturing sector in developed countries to the different innovation and appropriability dynamics of other sectors and types of countries.

All that has been said in this brief introduction should be taken as a general warning for reading this section. When revising the strengths and weaknesses of the empirical literature produced so far and suggesting the research agenda, we will return to some of the points stressed above.

3.2 The Empirical Evidence: Main Findings

The findings of the literature reviewed for elaborating this paper could be organized along different axes. In our case, we have chosen to classify it under five headings, namely: (1) the ranking of the effectiveness of the different appropriability methods as perceived by private firms; (2) the determinants of firms' perceptions about the effectiveness of each appropriability tool; (3) the motives for patenting; (4) the determinants of firms' patent propensities; and (5) appropriability strategies in developing countries. In what follows the main results found for each subject in the available literature are surveyed.[9]

3.2.1 The Effectiveness and Use of the Different Appropriability Mechanisms

The pioneer studies on patents and appropriability (Scherer *et al*, 1959 for the US and Taylor and Silberston, 1973 for the UK) showed that patents were important as a means to profit from innovation only in the pharmaceutical industry. Later on, Mansfield (1986) found – based on the firms' own answers – that only in the pharmaceutical and chemical industries a large number of innovations would not have been developed or introduced in the market without patent protection, although, at the same time, the survey showed that firms patented most of their patentable inventions. A similar conclusion had already been reached in Mansfield *et al* (1981).

The limited importance of patents for innovative firms received further confirmation in a study by Levin *et al* (1987) who, in 1983, asked 650 R&D performing manufacturing firms in the US about their preferred methods to protect innovations. In 1994 a new study was made on a similar basis involving 1,478 US firms employing from 20 to more than 100,000 workers (Cohen *et al* (2000)). A distinctive feature of these studies was that they included other appropriability means such as secrecy, lead times, moving rapidly along the learning curve and complementary sales, services and manufacturing facilities.

A main finding was that firms valued secrecy, lead times or complementary sales, services and manufacturing facilities more than patents in most sectors. In fact, for the whole sample, patents only ranked above "other legal mechanisms" (such as trademarks) in terms of their effectiveness to protect innovations. In turn, secrecy and lead times were the preferred methods.

In the 1994 survey patents were not deemed to be the most effective protection mechanism in any industry, although they ranked high in drugs, medical equipment and special purpose machinery (for product innovations). As expected, patents were deemed not to be very effective in protecting product innovations in low-tech industries such as food, textiles and printing and publishing, or in traditional heavy branches such as steel. However, patents also ranked low in high-tech industries such as electronic components, semi-conductors, precision instruments and communication equipment.

In turn, it was found that secrecy and/or lead time were deemed as the most effective mechanisms in almost all industries, except printing/publishing, glass, concrete and cement and electronic components, where complementary sales and manufacturing capabilities were the most effective strategies.

Lead time was judged as the most effective mechanism for product innovations, followed by secrecy and complementary assets. In the case of process innovations, secrecy was much more important than lead time – it is easier to keep process innovations secret than product innovations – but complementary manufacturing capabilities also emerged as a very relevant appro-

priability tool. Patents were relatively more important for product innovations than for process innovations.

Cohen *et al* (2000) found that, in fact, there were three different appropriability strategies in the manufacturing industry: one based on lead time and complementary capabilities, another based on legal mechanisms (especially patents) and another based on secrecy. However, firms tended to use more than one appropriability method, simultaneously as well as sequentially.

Both 1983 and 1994 surveys asked about the reasons why firms did not use patents. Disclosure and ease of inventing-around were the most important reasons, together with lack of novelty of some inventions. In turn, the costs of applying and defending patents proved to be important reasons for not patenting among small firms – there was a correlation between firm size and whether the respondent indicated the cost of defending a patent in court as a reason for not patenting.

The availability of data similar to those generated by the 1983 and 1994 US surveys allowed the replication of the Levin *et al* (1987) and Cohen *et al* (2000) studies for many other countries. In the case of Europe this was possible to a large extent thanks to the launch of the Community Innovation Surveys (CIS).

Arundel (2001), for instance, analyzes the relevance of different appropriability methods on the basis of the results of the 1993 CIS for Belgium, Denmark, Germany, Ireland, Luxembourg, the Netherlands and Norway. The survey only covers innovative firms, that is, those firms that introduced a new product or process between 1990 and 1992, and the author concentrated, within this group of firms, on those that perform R&D on a continuous basis.

Lead time was the mechanism deemed by far the most effective, both for product as well as for process innovations. Followed in order of decreasing relevance by secrecy, design complexity,[10] patents and design registration. The reasons for not trusting in patents were similar to those mentioned for the US case.

Cohen *et al* (2001) undertook in Japan a study similar to those recently mentioned for the US and Europe, on the basis of a sample of large R&D performing manufacturing firms. The report shows wide differences in the use of appropriability methods in Japan *vis à vis* the US and Europe. All appropriability methods, except patents, were deemed as less effective than in the US. The ranking of methods also differed. Secrecy was judged as the least effective method for protecting product innovations, while patents were considered almost as effective as lead time and manufacturing capabilities. In turn, in the case of process innovations, complementary manufacturing was the most effective appropriability mechanism, while secrecy and lead time followed.

In the same vein, Laursen and Salter (2005) studied the use of appropriability methods in the UK industry dividing them into legal – design registrations, trademarks and patents – and first mover – secrecy, design complexity and lead time. Like the other studies mentioned above, they found that first mover mechanisms (which are similar to what we have called "strategic") were the most relevant. Trademarks and patents seemed to have, on average, the same effectiveness. The authors found differences in appropriability strategies by industry, but in all of them first mover mechanisms were deemed as the most effective. In turn, the relevance of appropriability mechanisms in general was higher in sectors such as chemicals (which include pharmaceuticals), machinery and electrical *vis à vis* food and drink, textiles, wood or paper and printing.

Harabi (1995) studied a panel of Swiss firms actively engaged in R&D activities, almost all of them in the manufacturing sector. Lead time ranked first for protecting process innovations and second in product innovations – for product innovations the preferred method was superior sales and service efforts. Patents were considered the least effective method both for process as well as for product innovations. The author found that only in some sectors – namely chemical products for plant protection, cosmetic products, chemical products (including drugs) and agricultural tools and equipment – was patent effectiveness relatively high. The ability of imitators to invent around patents was regarded as the most important constraint for patenting, followed by information disclosure.

Konig and Licht (1995) studied a sample of German manufacturing firms and found that non-legal IP mechanisms were more effective than legal tools. They found every non-legal IP protection tool more effective for protection of product innovations than patents.

Sattler (2002) analyzed a panel of German industrial firms that had introduced or planned to introduce new products. The descriptive analysis shows that the ranking of effectiveness was as follows: long-term employment relationships, lead time, design complexity, secrecy, patents and design registrations. A wide variance in the data was found, especially regarding patent effectiveness. On the basis of this finding, the author performed a cluster analysis and found that 20 per cent of firms deemed patents as the most effective method. In turn, chemicals (including pharmaceuticals), mechanical engineering and steel/basic metals were the industries where patents were perceived as more effective (and the magnitude of these sectoral effects was relatively high).

Blind *et al* (2006), on the basis of a survey of German firms significantly involved in patenting activities, studied the use of different appropriability mechanisms as well as the motives for patenting. The sample on which the authors based their analysis covered a wide range of appropriability methods, both formal (patents, abroad and domestic, trademarks, utility models, copyright, designs) as well as informal (lead time, long-term contracts with workforce, exclusive relations with customers, secrecy, suppliers' contracts). Although the sample was restricted only to firms with patents, lead time was still considered the most important protection mechanism. However, unlike other studies, patenting abroad and at home ranked second and third, respectively. Secrecy, in turn, ranked below exclusive relations with customers and at the same level as trademarks.

Gonzalez-Alvarez and Nieto-Antolin (2007) studied a panel of Spanish manufacturing firms. The mechanism that was mostly used was what the authors called continuous innovation (which, according to them, could be assimilated to lead time), followed by time and cost for imitation (related to the complexity of innovation), secrecy and patents.

Hurmelinna and Puumalainen (2007) studied a sample of Finnish R&D performing manufacturing firms. Descriptive statistics show that in terms of the effectiveness of appropriability mechanisms, the ranking was as follows: lead time, technical/practical means (secrecy, passwords, limited access), tacitness, contracts, IPRs (patents, trademarks, copyright, utility models, designs, trade secrets), labor legislation and human resource management.

Hanel (2005) studied a panel of Canadian manufacturing firms focusing on the use of legal IPRs, not including other forms of appropriability. Two-thirds of manufacturing firms in Canada used at least one form of IPR. Confidentiality agreements were by far the most popular IPR method, followed by trademarks. Patents and trade secrets were used by nearly a quarter of Canadian firms.[11] Although pharmaceutical firms made more intensive use of IPRs, in the case of patents, higher use was found in agricultural, construction and mining machinery followed by electrical

equipment and appliances. The top users of trade secrets were producers of semi-conductors and other electronic equipment, while in the computer industry confidentiality agreements were the preferred method. Low-tech sectors, in turn, relied more on trademarks. More generally, firms in high-tech sectors were more likely to be users of IPRs *vis à vis* those in low-tech industries. The study also showed that firms that introduced product and process innovations and only product innovations used IPRs more frequently (by "frequently" the author means the percentage of firms using IPRs within each group) than process-only innovators. This finding is observed even for trade secrets.

As mentioned before, there are very few studies that aim to learn about the usage of appropriability mechanisms in the service sector. One of those studies is that of Baldwin *et al* (1998) who analyzed the communications, financial and technical business service sectors. The study asked about the use of different appropriability devices as well as about their effectiveness. In terms of use, the report showed that fewer than half of the innovators in each industry reported using any of the IPRs available to them. In general, copyright and trademarks (specially employed in the financial services industry) are the more commonly used instruments. Trade secrets rank third in each industry, while patents are only used in the technical business service sector.

Regarding the perceived effectiveness of the different appropriability methods, the survey also included two "strategic" mechanisms, namely, being first to the market and complexity. Being first to the market is ranked as the most effective method in the three industries. Trademarks – which are key for attracting and retaining customers – ranked second in communications and financial services, while complexity occupied that place in technical business services and ranked third in communications and financial services. Patents were not seen as highly effective in any sector, while trade secrets were important in technical business services (a finding that Baldwin *et al* attributed to the fact that most firms in that industry were small) and the same occurred with copyright in communications.

Paallysaho and Kuusisto (2006) studied a sample of Finnish and UK firms in three knowledge-intensive service sectors: software consultancy and supply, business and management consultancy services and advertising. Most firms were small and medium-sized and their sales came mostly from tailor-made services. As expected, patents were used very little (software firms had a relatively higher rate of use), while trademarks and copyright dominated in the field of formal IPRs. However, by far the most used appropriability mechanism was restrictive contracts (85 per cent of the surveyed firms used contracts, against 36 per cent in the case of trademarks). These contracts included requiring employees to sign non-disclosure agreements or non-competition clauses.[12] The use of legal instruments was often complemented by informal means, such as secrecy (which was widely used by the firms sampled in this study), publishing, restrictions on access to information, enhancing personnel commitment and implementing schemes of fragmentation and rotation of duties.

Hipp and Herstatt (2006), studying a panel of service-intensive German firms, concluded that the preferred protection tool was internal lock-in (long term labor contracts), followed by secrecy, first-to-market, complex design and lock-in of customers and suppliers. Only 6 per cent of the firms used formal IPR strategies, mainly in the information and telecommunications and media cluster. Moreover, most companies used a combination of two or more protection mechanisms, especially secrecy and first-to-market with lock-in strategies.

Blind *et al* (2003), based on data from CIS-2, found that the propensity to patent as well as the number of patent applications was significantly lower in services compared with manufacturing. (According to the CIS-2, 7 per cent of service firms had applied for patents, compared with

25 per cent in the manufacturing industry.) The activities within the service sector where patenting was most common are R&D and business-related services and telecommunications. From case studies of 65 service companies across the European Union, the authors found that the protection mechanisms perceived as most important were trademarks, secrecy, customer relationship management and lead-time advantages, in that order, while patents were the least important formal method. However, in general both formal and informal appropriability tools had only average relevance in the innovation strategies of service companies. The most important reason for not patenting was that new services included tacit knowledge and were thus not eligible for patenting.

Mairesse and Mohnen (2003) compared the protection methods used by manufacturing and service firms drawing on data from the French CIS-3 survey. Trademarks, complexity and lead time were the most widely used appropriation methods in the service sector; patents ranked fourth along with secrecy. Although innovative service companies employed appropriability methods less often than those in high-tech manufacturing sectors, the contrary occurred when they were compared with innovators in low-tech sectors.

Beyond the literature based on quantitative evidence summarized so far, there are also a number of interesting papers based on case studies. Davis and Kjaer (2003a) studied patent strategies of small Danish firms in high-tech sectors (telecommunications, software and pharmaceutical-related biotechnology). Patents were a crucial appropriability means in the telecommunication industry, especially for products (processes were more prone to be protected by secrecy). However, patents were not enough to secure appropriability, and were complemented by other means such as R&D staff learning and experience (tacit knowledge). In contrast, patents were rarely used in the software sector. Lead time and continuous product development, along with sales and customer relations, were considered effective appropriation mechanisms in this sector. In the case of biotechnology, patents were considered the best means to secure appropriability. Other means were not considered feasible. For instance, lead time was not practical for inventions with long development times, subject to extensive testing and government approval, while complementary sales and marketing capabilities did not matter since, by the time the product was marketed, the innovating firm and/or the innovation had most likely been taken over by a larger firm. Regarding obstacles, the authors stated that size affected small firms in several ways, for instance, increasing the difficulties of detecting and pursuing infringers, and for using blocking patents. Davis and Kjaer's (2003b) findings in their study on the appropriability strategies of small biotech firms in Medicon Valley, a cluster of biomedical firms in Scandinavia, confirmed that in this sector patents were considered as the only effective means of appropriation. Patenting strategies were based on an international approach, securing protection in all markets of interest for the firms. Similar to the findings of the study mentioned above, although the authors dealt with small firms, they were not concerned about litigation costs and other factors that usually deter that kind of firm from patenting because, by the time the patented product was commercialized, it would likely be owned by a large pharmaceutical firm.

In turn, Dahlander (2004) focused on the software sector, but dealt with open-source firms in Sweden and Finland. The study was based on firms' interviews, and showed that patents were not used by those firms which relied on secrecy and copyright but mainly on lead time and network externalities (attracting a large user base and moving down rapidly through the learning curve).

3.2.2 The Determinants of the Perceived Effectiveness of the Different Appropriability Mechanisms

Arundel (2001), in his study based on firms from seven European countries, analyzed whether firm size influenced opinions about the relative importance of different appropriability mechanisms. His study showed that both for product as well as for process innovations, firms of all sizes considered secrecy more relevant than patents. In the case of product innovations, it was shown that the relative importance of secrecy declined with the increase in a firm's size, while no change was observed in the case of process innovations. If the analysis focused on R&D intensive firms,[13] it also found that firms of all sizes deemed secrecy more effective than patents. However, the author found that R&D-intensive SMEs gave more importance to patents than SMEs with small R&D expenditures.

Having found that SMEs deemed secrecy more effective than large firms, Arundel (2001) stated that this was not due to the fact that the former had less patentable innovations, since the study only covered firms with R&D expenditures. On the contrary, the author suggested that other factors could explain that finding, e.g. the lack of financial resources for lawsuits.

Other relevant findings of this study were as follows: (1) firms that spent a high percentage of their R&D expenditures on process innovations were more likely to use secrecy; (2) participation in cooperative R&D arrangements reduced the probability that a firm would prefer secrecy to patents, a fact that provided some evidence for the argument that patents help to clarify ownership in those arrangements; (3) firms tended to prefer secrecy when disclosure was a serious disadvantage for patenting.

Sattler (2005), based on a sample of German firms, in order to learn about the determinants of the probability for a firm to belong to the cluster in which patents are deemed as highly effective, used a number of predictors related to the degree of innovativeness of a firm's products and the R&D strategy of the firm. The author found that those predictors explained only a small fraction of the variance. In fact, only the variables related to the existence of cooperative R&D arrangements and the firm's R&D intensity had significant and positive effects on the perceived effectiveness of patents, while the degree of innovativeness of the firm's new products and the length of product life cycle had almost no explanatory power. Large firms also perceived patents as more effective than did SMEs. However, the factor that turned out to be the most relevant was the number of patent applications, meaning that patenting firms deem patents more effective than non-patenting firms.

Blind *et al* (2006) also based on a panel of German firms, showed that while only small differences in the importance attributed to patents were found when dividing firms by sectors, larger firms attached more relevance to patents than did SMEs. They also suggested that there was almost a linear relation between size and the existence of patent departments.[14]

Byma and Leiponen (2007) studied a panel of Finnish SMEs, mostly located in high-tech sectors. The authors found that as the firms' size increased so did the relevance attributed to patents. Firms that launched process innovations and were in high-tech industries were more likely to emphasize trade secrets, while speed (a concept close to lead time) was the preferred appropriability method for the smallest and for the highly R&D-intensive firms, as well as for firms operating in low-tech industries. The lack of relevance of patents for SMEs was shown, according to the authors, by the fact that even R&D-intensive small firms do not choose patents as their preferred mechanism to protect intellectual assets, but rely mainly on speed.

A distinctive contribution of this paper is that the authors found evidence that vertical innovation cooperation has significant implications for appropriability strategy. Firms engaged in that

kind of collaborative arrangement were statistically significantly more likely than other firms to rely on speed instead of secrecy. The authors interpreted this finding arguing that firms in their sample were most probably dealing with partners larger than themselves, in which case they are in a relatively weak position to appropriate intellectual outputs from joint work. Patenting may not be a feasible strategy due to lack of resources, while secrecy is not likely to work in collaborative agreements, which leaves speed as the only effective appropriation mechanism available.

Hurmelinna and Puumalainen (2007), also based on a sample of Finnish firms, tried to correlate the use of different appropriability mechanisms with differences in the availability[15] and the perception of the relative strength[16] of each one, as well as with the differences in firms' strategies. The authors confirmed the hypothesis of a relationship between the strength and the use of different appropriability mechanisms – i.e. the stronger the mechanism, the more it is used. However, they also found that in the case of IPRs, when availability was low, usage was low regardless of the strength, while when IPR availability was high, the level of usage depended on the strength.

On the contrary, the results for the relation between strategies and appropriability were not as clear-cut. A positive relationship was found between pursuing short-term value creation and the use of lead time, while IPRs were not used for that objective, perhaps because they were too time-consuming. The use of IPRs, in turn, was negatively associated with the creation of long-term value.

Gonzalez-Alvarez and Nieto-Antolin (2007), on the basis of a panel of Spanish firms, found that firms that use mostly explicit (codified) knowledge and those of larger size were more prone to using patents. Firms that employed tacit knowledge preferred secrecy, while those that develop complex technologies tended to choose imitation cost and time as their preferred protection mechanism, and those highly committed to more intensive human resource practices tended to choose ongoing innovation (lead time) – employees must be motivated in order to follow a strategy of continuous innovation.

The study of Combe and Pfister (2000) focused on patent effectiveness on the basis of data of innovative manufacturing firms, taken from a survey of the Statistical Department of the French Ministry of Industry (SESSI) on patents and appropriation tools. The authors found that patent costs did not exert a negative influence on patent effectiveness, with disclosure the only significant limit to patent effectiveness. Large firms tended to judge patents as being more effective *vis à vis* SMEs. The paper also found significant differences in the effectiveness of product *vis à vis* process patents, as follows: (1) process patents were more prone to be substituted by secrecy as a protection mechanism than product patents; (2) patent disclosure was seen as a more serious obstacle for product patents than for process patents; (3) the existence of an IPR department within a firm was complementary to patent effectiveness for process innovations but not for product innovations; (4) advertisement intensity and large market shares were more important for effectiveness of process patents than for product patents, while the opposite held for first-mover advantage and for strategies based on frequent innovations.

Hanel (2005), based on data from Canadian firms, found that the use of all IPR methods increased with firm size; the only exception being that small firms used trade secrets less frequently than medium-sized firms. R&D performing firms were more likely to use IPRs than other firms, while world-first innovators and, to a lesser extent, Canada-first innovators were also more likely users of IPRs than other firms.

Hanel also attempted to relate firms' strategies with the use of IPRs. Firms that base their competitive strategy on the development of new markets are likely to use IPRs such as trademarks, trade secrets and confidentially agreements, but not patents. In contrast, export strategies are not associated with the use of any IPR. In turn, firms receiving government assistance in the form of R&D subsidies or tax credits use IPRs more frequently than other firms.

Further extending his analysis, the author distinguished two groups of firms within his sample. One comprised firms that used patents and trademarks. Firms in this group received R&D government subsidies and introduced world-first innovations. Larger and high-tech firms within this group were most likely to use patents. The second group was that of firms which relied primarily on trade secrets. This comprised firms that introduce mainly Canada-first innovations and are less oriented toward product innovations than the first group. Larger firms were more likely to use trade secrets than SMEs.

Finally, Canada-first innovators tended to apply for patents exclusively in Canada. The only other factor that increased the probability of applying for a patent in Canada was size and conducting R&D. Firms that applied for patents in the US were world-first and Canada-first innovators that conducted R&D and were mostly US-owned firms. Most firms that patented both in Canada and the US were medium and large-sized firms and successful exporters that conducted R&D by contracting it out.

3.2.3 Motives for Patenting

Cohen *et al* (2000) also explored the reasons why firms patented beyond the aim of making profits through the direct exploitation of patented inventions. The ranking was led by prevention of copying, followed by patent blocking and prevention of suits. Reputation enhancing and use in negotiations were other reasons why firms patented, while earning licenses was the least important motivation – which means that selling knowledge in disembodied forms was not a main reason to patent. The authors also found that the motivations for patenting differed in "discrete" *vis à vis* "complex"[17] product industries. In the former, firms often use patents for blocking the development of substitutes by rivals, while in the latter, to force rivals to enter in negotiations is more common.

Other studies also aimed at analyzing the so-called "patent paradox" stemming from the gap between the relative ineffectiveness of patents as an appropriability mechanism and the sharp rise in patents applications. Hall and Ziedonis (2001) engaged in this task in the case of the semi-conductor industry. Their findings showed that the increase in patent propensity in this industry was the outcome of two trends related to the use of patents for "strategic" reasons: (1) large scale semi-conductor manufacturers engaged in patent portfolio races in order to reduce concerns about hold up by external patent owners and negotiating access to external technologies on more favorable terms; (2) newcomers have higher patent propensities since these rights are crucial for attracting venture capital and securing property rights in niche product markets.

Regarding studies for other countries, Cohen *et al* (2001) found that strategic uses of patents were more pervasive in Japan, but that compared to US firms, Japanese firms are less likely to use their patents as a means of exclusivity (what the authors call a "fence" strategy) and much more likely to use them as a means of gaining market access and freedom to operate and design (the "player" strategy). Cohen *et al* (2001) attributed the differences in patenting strategies to the differences in national regulations.

In turn, Harabi (1995), in his study based on a panel of Swiss firms, showed that although patent effectiveness for preventing imitation and securing license fees was not deemed to be very high, patents could enhance the patent holders' negotiating position with third parties.

Blind *et al* (2006), with data from Germany, found that the most important motive for patenting was not protection from imitation but securing European markets: defensive blockade of competitors (securing own technological flexibility); securing national markets; improvement of technological image and offensive blockade of competitors (hindering competitors from technological development) follow at a relatively close distance. The authors grouped the motives for patenting in five categories for undertaking factor analysis, and found that protective motives (protection from imitation and safeguarding markets) and blocking motives have almost the same relevance, followed by reputation motives. In turn, large firms are more prone to emphasizing new strategic motives for patenting, such as those labeled by the authors under the "exchange" (amelioration of position in cooperation arrangements, improved access to capital markets, exchange potential, licensing) and "incentive" (motivation of staff, internal performance indicator) categories.

Duguet and Kabla (1998) analyzed motivation for patenting by innovative French manufacturing firms. Almost all of them stated that preventing imitation was one of their motivations, while more than 60 per cent quoted motives such as avoiding litigation and using patents in technology negotiations.

Thumm (2003), (2004) analyzed Swiss biotechnology firms' motives for applying for patents, based on the results of a survey conducted by the Swiss Federal Institute of Intellectual Property. The author showed that the reasons firms gave for patenting their inventions included acquisition of venture capital (an important motive for small firms) and cooperation with other companies and research institutes (which is more relevant for large firms). As offensive patent strategies (such as patent blocking) are not widely diffused, the author stated that this could be due to the "discrete" nature of the biotechnology industry.

3.2.4 Patent Propensities [18,19]

In a paper with data for the Netherlands, Brouwer and Kleinknecht (1999) found that, given a certain innovation output, larger firms and firms belonging to hightechnological opportunity sectors and those which have R&D collaboration agreements had a higher propensity to patent (defined as the probability for a firm to apply for at least one European patent). However, given a firm with some patent applications, the number of applications increased less than proportionately with firm size. According to the authors, since they found that smaller innovators who do apply for patents had relatively higher numbers of patents, they could conclude that small innovators used the patent system as compensation for having less market power than larger firms.

Hussinger (2005) worked with a sample of German manufacturing firms that undertake R&D and are product innovators. The factors that explained patent propensities (measured in terms of firms' patent applications in the German Patent Office) were the patent stock – firms are seemingly committed to patenting – size, secrecy – apparently firms tend to use both appropriability mechanisms – and the fractions of firms in an industry that uses patents. R&D intensity has no impact on patent propensity.

Arundel and Kabla (1998) analyzed patent propensities – measured as the percentage of innovations for which a patent application is made – on the basis of a database comprised of large

European firms. Patent propensities for product innovations were higher than for process innovations. In the former case, the sectors with higher propensity rates were pharmaceuticals, chemicals and machinery, while textiles, clothing and basic metals had the lowest patenting rates. Patent propensity rates both for product and process innovations increased with firm size, with the perception of patents as being an effective protection method and with the intensity of the competition faced by the firm, while R&D expenditures had no effect. Secrecy was also positively correlated with patenting in the case of process innovations, meaning that both mechanisms could be protecting different types or aspects of process innovations. Exporting firms were also more likely to patent, especially in the case of product innovations.

In their study on the semiconductor industry, Hall and Ziedonis (2001) found that R&D expenditures had a positive impact on patenting, together with size and a firm's capital intensity (patent propensity is defined as the probability that a firm applies for a patent). The impact of R&D fell sharply when size effects were included – the latter being four times higher than the effect of R&D.

Licht and Zoz (1998), using data from the first wave of the Mannheim Innovation Panel, examined the connection between firm size and patent applications. As expected, their results showed that large firms were more likely to apply for patents and have more patents than SMEs. Additionally, large firms often applied not only to the German Patent Office but to the European Patent Office (EPO) as well, contrary to SMEs. Exporters also showed a higher patent propensity (both in terms of the decision to patent as well as of the number of patents). R&D expenditures also had a positive influence on patenting, with elasticity close to one, a result similar to that found by Crepon and Duguet (1996). No spillovers or patent rivalry effects were found (that is, other firms' R&D behavior did not affect patent propensity). In turn, firms which regarded scientific institutions as a relevant source of information for their innovation activities applied more often for patents.

Cincera (1997) studied a sample of 181 firms belonging to the group of the most important international firms conducting R&D. He found that R&D expenditures were positively associated with patent behavior (measured by patent applications at the EPO); when a firm spends 10 per cent more R&D in t-1, it applies for 6 per cent more patents in t, while an increase of 10 per cent of current R&D implies an increase of 3.5 per cent of patent applications in the same year. In turn, the author also found that technological spillovers (measured by the R&D performed by other firms) also had a positive impact on patent applications. However, it must be noted that the author was not able to control for other characteristics of the firms, such as size.

Nagaoka and Nishimura (2006) studied the effect of cross-licensing and patent thickets[20] on the propensity to patent with data for the Japanese manufacturing sector. The main idea is that in industries where one or both phenomena are relevant, patent propensities are higher, since a firm in that kind of industry will try to patent its inventions which will be used by other firms in the future so that it can use the other firms' technologies through cross-licensing. Their findings supported this hypothesis.

Chabchoub and Niosi (2005) studied the propensity to patent – measured as the probability of a firm to have a patent at the USPTO – in the software industry in the US and Canada. They found that firms located in clusters and those with a higher share of products (relative to services) in their revenues had higher probabilities of obtaining patents. In turn, large firms not only have a higher propensity to patent but also obtain more patents than smaller firms.

Duguet and Kabla (1998) analyzed patent propensities (defined as the number of innovations that are patented), on the basis of a panel of French manufacturing firms, and found that dis-

closure is the main reason why firms do not patent all their innovations. In turn, R&D expenditures have a positive influence on patent propensity. Costs, in turn, do not seemingly have an influence on patent decisions. The variables that have an influence on the number of patent applications are R&D expenditures, the use of patents to avoid litigation and the use of patents to strengthen technology negotiations. Size only has a positive influence when industry effects are not considered.

López and Orlicki (2007) analyzed patent propensities – defined as the probability for a firm having been granted a patent – in Argentina, using econometric techniques and found that size, foreign ownership and the skill intensity of the workforce were all factors that had an influence on the probability for a firm to obtain patents and on the number of patents obtained. Foreign ownership is the variable with higher impact, confirming the above-mentioned hypothesis that TNCs affiliates could be more likely to apply for patents in developing countries since they could revalidate rights obtained elsewhere. Sectoral specificities also have an impact on the probability of obtaining patents.

Faced with the almost universal finding of a positive relationship between firm size and use of patents, Jensen and Webster (2004) found that the common approach of those studies was flawed because it failed to take into account that it is the rate of usage and not the absolute level that is of interest; hence, we should investigate whether there are systematic differences in the number of IPRs per employee among firms of different sizes. The authors explored this issue with a database of Australian firms. The descriptive statistical analysis showed that SMEs had lower patent application rates and higher trademark application rates than large firms. However, econometric estimations revealed that size had an influence on patents not on trademark applications per employee (although large firms had a higher rate of design applications per employee). Nonetheless, their findings should be taken with care since they lack a number of control variables at firm level that could significantly affect the results (and they assume that the innovative potential of a firm is dictated by the number of employees; a strange assumption). Furthermore, the methodology applied by the authors is quite obscure and not very reliable, especially from the econometric point of view.

3.2.5 Appropriability Strategies in Developing Countries

Among the few studies with data for developing countries, there is one by Hu and Jefferson (2006) which analyzed the patent behavior of a sample of large and medium-sized manufacturing firms in China. The variable of interest is patent applications – although the authors stated that results do not change when they use patent grants. R&D expenditures have a positive influence on patenting, although the estimated elasticity was much lower than that reported for studies in the US and Europe. While R&D makes a significant contribution to patenting in Chinese firms, the same does not happen with foreign firms – this could mean that they file patents on behalf of their parent companies or that, even if they obtain patentable inventions, they assign them to their parent companies. The presence of FDI in an industry also stimulates patenting, both by foreign as well as by domestic firms. Patenting also increases with firm size. The authors also found differences in the factors explaining patenting rates by industry. R&D is important in electric and special machinery and electronics, while size effects are more noticeable in beverages, pharmaceuticals, electric machinery and electronics.

In turn, Basant (2004) quoted a study of 120 Indian information technology (IT) firms (Gupta (2004), in which firms were asked about the effectiveness of different appropriability mechanisms. The results suggested that better lead times and access to good marketing and distribution facilities were the most critical for profiting from product and process innovations, followed

by brand building. Patents and copyright were considered to be more effective than inimitability due to complexity and secrecy for both product and process innovations. As in other studies, patents were perceived as more effective for product than for process innovations.

López and Orlicki (2007) revised the scant empirical evidence on appropriability strategies in Latin America. As to the situation in the larger Latin American countries, the authors found that no more than 10 per cent of innovating firms used patents – a figure clearly below that observed in developed countries – and that among them larger and foreign-owned firms prevail as well as firms operating in sectors such as chemicals (including pharmaceuticals), machinery and the electric and electronic industries.

Trademarks are by far the most commonly employed IPR in Latin America, a fact that could reflect the predominance of a competition pattern more based on product differentiation than on genuine innovation. As for the so-called "strategic" mechanisms, only in Brazil is there data available, which shows that firms use them much less than their peers in developed countries – only in larger Brazilian firms is lead time relatively important as an appropriability mechanism. In turn, while small firms prefer secrecy to patents, the opposite is the case with medium and large firms (although in all cases trademarks are the device most often employed).

Latin American firms use all appropriability mechanisms less than their counterparts in developed countries, but differences are greater when it comes to "strategic" mechanisms. Furthermore, differences in the use of all appropriability mechanisms are greater for SMEs. The only exception seems to be trademarks: Brazilian innovators use trademarks more frequently than their peers in some European countries, but the percentage who use patents is half that registered in Spain or Italy, while in the case of lead time differences are at least 8 to 1.

Brazilian data allows us to learn more about sectoral features of the use of appropriability mechanisms. Sectors in which firms have a higher patenting rate are automobiles, pulp and paper and medical, optical and automation equipment. Only in the latter and in autoparts are patents the predominant appropriation method. Interestingly enough, in pharmaceuticals, only 14 per cent of innovators use patents, while 44 per cent use trademarks. Trademarks have a very high rate of use in other sectors such as informatics, beverages and automobiles – in all of them TNC affiliates have a dominant presence. Secrecy is often used in automobiles, a sector which also ranks high in the use of lead time, together with pulp and paper and informatics.

4. THE EMPIRICAL LITERATURE: SUMMARY OF RESULTS, STRENGTHS, WEAKNESSES AND LIMITATIONS

It is not an easy task to draw sound conclusions from the literature revised in this paper. There are significant differences in terms of objectives, questions, methodologies, types of firms, nature of databases, etc. which often make it difficult to compare the findings of the papers surveyed. When the same findings appear in many of these, often very different studies, we can be confident that they are relatively reliable. The problem occurs when results differ, since it is problematic to learn why these differences exist. However, in spite of these difficulties, there are a number of findings that, in our view, emerge as more or less "sound" from the literature reviewed.

(i) Firms tend to employ different appropriability mechanisms. Sometimes they do it sequentially – e.g. an invention is protected by secrecy at a early stage and later on is patented – and at other times simultaneously – e.g. because an invention comprises many elements that can be protected through different appropriability tools.

(ii) Lead time and secrecy seem to be the most relevant appropriability devices for most sectors and innovation types. Manufacturing and marketing capabilities – an appropriability mechanism which is not always considered in the studies surveyed – also provide a very relevant tool for protecting innovations.
(iii) Large firms have a higher propensity to patent and they judge patents as a more effective appropriability method than do SMEs. However, this does not necessarily mean that, once they decide to apply for patents, they have more patents than SMEs (since some studies show that larger firms have more patents than patenting SMEs, while others fail to find that result).
(iv) Although patents are not the most effective method for protecting innovations, many firms employ them anyway, be it jointly with other appropriability methods or not only as a means to protect their innovations but to achieve other objectives – i.e. "strategic patenting" (patent blocking, prevention of suits, reputation enhancing, cross-licensing, attracting venture capital, etc.).
(v) Disclosure and ease of inventing-around are the most important reasons for not patenting.
(vi) Patents are more relevant as an appropriability mechanism for product than for process innovations and for some sectors such as chemicals (especially pharmaceuticals), some machinery industries and biotechnology.
(vii) SMEs that display aggressive patent strategies often do not have the intention of exploiting their inventions but aim to license or sell them, among other factors, because they lack the production and marketing capabilities (complementary assets) needed for successfully commercializing these inventions.
(viii) There seem to be "patenting clubs" among manufacturing firms. That is, firms that have more patents and/or perceive patents as an effective appropriability device, tend to have higher patent propensities – in other words, patenting decisions would be related to the firm's patenting history and its perception of the strength of patents as a protection tool.

In turn, there are other issues for which some evidence exists but more research is needed since they have been analyzed only in a few studies. For instance, the relations between the decision to use some appropriability mechanisms and the existence of different cooperation strategies in innovation activities and/or the adoption of different technological and/or business strategies; the impact of the existence of patent thickets or cross-licensing strategies on patent propensities; the fact that while tacit knowledge is in itself an appropriability mechanism – which may need to be protected mainly through human resource management and labor contracts – codified knowledge is more protectable through patents.

The interaction among different appropriability mechanisms is another issue that has been addressed in the literature and deserves further attention. For instance, it has been found that firms use different protection mechanisms and that some of them may even be positively associated – for instance secrecy and patents – but the fact that most surveys inquire about the use of appropriability tools without asking which inventions are protected by each tool (and at what stage of the innovation process) make it difficult to learn more about the relations and interactions among the bundle of protection devices available to firms. The sequence in which different protection mechanisms are used, as they are more or less appropriate for the different stages of the life-cycle of an invention, is also an issue deserving more attention.

Furthermore, some other subjects have led to contradictory findings in the literature. This is the case of the relations between R&D and patenting, for instance, since some studies find a positive impact of R&D on patent activities – and even find relatively large elasticities – but others fail to detect such a relation.[21] Although this survey has not entered into detail about methodological issues, there is an aspect of the empirical literature on this subject that needs to be studied in more depth. Most studies assume that there is a relationship between contemporaneous

R&D and patent applications/grants. This is justified in the literature on the basis that the lags between R&D and patenting are poorly identified because of the high in-firm correlation of R&D spending over time. Besides, as stated by Hall and Ziedonis (2001), when many lags are included, the estimate of the sum of the coefficients is roughly the same as the estimated coefficient of contemporaneous R&D when no lags are included. However, although this could be the case for a number of firms that have routinized their R&D activities, this is not the case for most SMEs that may undertake those activities sporadically. Hence, in this case, it would be wrong to assume that the above-mentioned contemporary relation exists, since the observed patents could be the result of R&D activities undertaken many years earlier.

Although the research produced so far has provided us with some answers on many relevant issues, it has also opened up new questions that have not been systematically explored. For instance, while there are a number of studies produced for different countries, the lack of a common methodology and the fact that they have often been carried out separately do not allow us to learn about the determinants of why firms in different countries display heterogeneous appropriability strategies – i.e. it would be very relevant to learn if there is a relationship between choosing certain strategies or having different patent propensities and the nature of the legal environment in each country.

In the same vein, SMEs have a lower patent propensity than do large firms. However, while there are a number of hypotheses that could explain this behavior, so far the issue has not been addressed systematically in the empirical literature.

There are other problems in the available literature, such as the lack of common definitions for some very relevant variables. This is the case of patent propensity, for instance, the notion of which is included under the heading "secrecy" or the definition of what is an innovative firm. The issue as to where firms patent is also insufficiently explored, although it could be very relevant for many countries.

One source of confusion specifically regarding patents is the fact that they are used for reasons other than protecting the results of an innovation. Insofar as patents seem to be less employed for traditional reasons and seem to be more relevant as strategic business tools, comparisons with other devices that are only relevant as protection tools may not be very informative. More systematic research about why firms patent is therefore needed and the studies should be careful both in the form they are carried out as well as in drawing conclusions on the subject.

As for the areas in which insufficient research has been produced, the innovation-appropriability dynamics in the service industry need to be further explored since, as mentioned earlier, there are very few studies on the subject and they cover only a small fraction of the service universe (although the general picture is similar to that found in the manufacturing industry regarding the relatively low effectiveness of patents as an appropriability tool). Moreover, while in the case of the manufacturing industry there have been a number of studies based on econometric methods, in the case of the service industry the evidence produced so far is mainly based on descriptive statistics or case studies. The lack of evidence on appropriability strategies is even more pronounced for the agricultural sector.

Even in the manufacturing sector, and although most studies include firms in low-tech sectors, the attention is focused on medium and high-tech sectors. Hence, there is also a need to explore more systematically which type of appropriability devices are employed by firms in low-tech sectors.

The same applies to other IPRs, such as trademarks, copyright, plant variety protection or utility models. All these mechanisms are or could be very relevant for different types of innovations, sectors and firms, but so far we know very little about the determinants of their use.

As mentioned above, many researchers have suggested that at least for some sectors or types of innovation there could be advantages in sharing knowledge and technologies in order to create network effects that could be a tool for reaping profits from their innovations. However, very little is known about the use of these types of mechanisms.

The same applies to the impact of new open innovation paradigms,[22] more based on collaborative research, on firms' appropriability strategies (Hurmelinna and Puumalainen (2005)). As suggested by West (2006), there are still many unresolved issues regarding the relations between appropriability and IPRs – in their different forms – and incentives for firms to engage in open innovation strategies.

Finally, as seen above, there are very few studies covering developing countries. The scant evidence they provide suggests that while some findings are common to those observed in developed countries – e.g. larger firms have higher patent propensities, sectoral factors have an impact on the observed patenting rates – there are other specific factors that need special attention –e.g. the relevance of foreign ownership on appropriability strategies, the scarce use of strategic appropriability methods, etc. Some research avenues to close the wide gap that exists at present in our knowledge regarding the innovation-appropriability dynamics in developing countries are suggested below.

5. A SUGGESTED RESEARCH AGENDA

On the basis of the comments in the preceding section, we put forward a number of issues that, in our judgment, deserve special attention in a future research agenda regarding the use of appropriability methods by innovative firms. Although many of the research issues are applicable both to developed and developing countries, some specific questions that are of special interest for the latter are mentioned below. Both econometric and case studies are needed in order to make progress in our knowledge about the subjects listed below:

1) Some studies have suggested that the contrasting patterns regarding the use of appropriability strategies between countries are related, to some extent, to the different nature of the respective patenting laws (e.g. Cohen *et al* (2001) in the case of Japan vs. the US). This type of study should be further pursued including not only patent policies, but also the IPR system in general, and even the functioning of the country's legal environment, especially regarding the key issue of contract enforcement. To undertake this task there is a need to gather international micro databases with information on innovation activities, appropriability strategies and other firms' characteristics that could have an impact on those strategies. Ideally, research methodology should go beyond using dummies for each country, since in that case we would only know that there are national factors that impact on the election of appropriability strategies but we would not know what mechanisms are underlying that effect.
2) Why do SMEs have lower patenting rates than larger firms? In order to learn whether this is due to the type of innovations launched by SMEs or to factors related to the mechanisms of IPR protection, systematic studies should be undertaken to obtain information at the firm level.
3) What is the relationship between the adoption of different business and innovation strategies and the use of specific appropriability devices? The same question applies to the rela-

tionship between tacit/codified knowledge and the use of appropriability tools. To gain knowledge about these subjects, current innovation surveys are perhaps not enough, and more in depth studies with qualitative information that may allow elaborating taxonomies of firms' strategies and knowledge bases are needed.

4) Although Teece's analysis of the innovation-appropriability dynamics has had a deep influence on the theoretical and empirical research agenda on the subject, some of his insights have not been explored as deeply as would have been desirable. This is particularly so for the role of complementary assets such as manufacturing and production capabilities (a factor on which only some surveys touch). The same is true for the relation between the existence of "dominant paradigms" in some sectors and the evolution of the role of IPRs along the technological trajectory of those paradigms.
5) Further surveys and case studies are needed to learn more about the interaction between the different appropriability mechanisms. First, it would be advisable for future studies to try to link the use and/or effectiveness of each appropriability device to specific innovations. Second, it would also be useful to analyze how a specific invention is protected through different tools at different moments of the innovation process. Third, the interplay of legal and strategic appropriability tools for protecting innovations should also be further explored.
6) There is a need to further analyze the relevance of strategic patenting and to distinguish more clearly the role of patents as a traditional appropriability mechanism from the new functions that patents may play in business strategies.
7) Although secrecy emerges as a very relevant appropriability mechanism, it is often the case that we do not know how firms keep their inventions secret. Furthermore, in some studies, secrecy appears as an alternative to other mechanisms that in fact are used to conceal firms' information (such as labor contracts). It would be useful, therefore, to advance in the decomposition of the heading "secrecy" in the different ways in which secrecy can be maintained.
8) As the dynamics of innovation change, new appropriability mechanisms could become more relevant. This is the case of human resource management practices, or the creation of network effects through knowledge sharing. In this regard, it is particularly important to analyze empirically the impact of appropriability and IPRs on open innovation, following the lines suggested by West (2006) and West *et al* (2006).
9) What are the determinants and motivations of the use of other IPR tools such as trademarks, copyright, plant variety protection, etc? Studies similar to those aimed at learning about patent propensities are needed to discover more about the factors that are behind the use of these alternative legal protection mechanisms.
10) The role of appropriability mechanisms in services and agriculture should be explored through the elaboration of surveys similar to those available in many countries for the manufacturing sector. Even within the manufacturing sector, the use of appropriability mechanisms in low-tech industries should be further explored. Naturally, those surveys should be adapted to the different dynamics of innovation and appropriability in each sector. For instance, in the case of the service sector, the role of specific mechanisms such as reputation should be explored (see Dolfsma (2004)).

Although, as mentioned earlier, most of these issues are also relevant for developing countries, it is clearly the case that there is a dearth of information about the use of appropriability methods in those countries. This is a major shortcoming in view of the often fierce debates around the IPR legislation in developing countries insofar as, without solid evidence on the determinants of the use of patents and other appropriability tools in those countries, debates are often based on purely theoretical notions, or, worse, ideological and/or *a priori* positions.

As far as we have been able to learn, only in Brazil is there an innovation survey that examines the use of appropriability mechanisms other than formal IPRs. More surveys and databases of this kind should be elaborated in other developing countries, in which firms are asked about their innovation strategies and the use of appropriability methods, as well as about other characteristics that could be affecting their behavior in terms of the innovation-appropriability dynamics. As long as those databases are systematically updated, more rigorous econometric techniques could be employed. These databases should include questions about the firms' expenditures on R&D and other innovation activities (including technology acquisition), their innovative outputs, the use of different appropriability devices and the effectiveness attached to each of those devices. Naturally, the evidence gathered through these mechanisms should be complemented with case studies aimed at learning about the qualitative aspects of the firms' decisions and strategies regarding the use of appropriability mechanisms (such as those undertaken some years ago by WIPO in many Latin American countries).[23]

However, as innovation processes and outputs have a very different nature and dynamic in developing countries *vis à vis* developed countries, simply transposing the same questions asked in studies made in the latter to the former could fail to shed light on why differences in the relative and absolute use of each appropriability mechanism exist and they may also miss the existence of other appropriability tools that could be specific to firms in developing countries.

Furthermore, there are some specific issues that should be addressed in future studies on the use of appropriability methods in developing countries, including: (1) the role of TNC affiliates, especially regarding the use of patents; (2) the decisions on where to patent, since for many firms it could be more relevant to patent abroad than in their home countries; (3) the use of utility models; (4) the impact of the often weak institutional environments of developing countries on the decisions of using legal appropriability methods (this is particularly important, for instance, in light of the uncertainty regarding contract enforcement in many developing countries).

A very relevant issue which is in need of rigorous research is the relationship between the scope, strength and enforcement of IPR legislation in developing countries and the dynamics of technological change. As mentioned before, there is a debate on whether tight or lax IPR regimes help or hinder innovation in developing countries, but so far the issue has not been explored systematically. Hence, there is a need to learn more about firms' perceptions regarding the impact of IPR legislation on the magnitude and objectives of innovation activities in those countries.[24]

Finally, it is perhaps the case that we lack a sound theoretical framework on the innovation-appropriability dynamics in developing countries. Therefore, not only empirical studies are needed, but also a clearer conceptual framework to understand the specificities of the use of IPRs and other appropriability tools in developing countries. Empirical studies and theoretical work should feed each other in order to obtain more knowledge on this key subject, something that is necessary not only from an academic point of view but also crucial from the perspective of policy-making both at the national as well as at regional and international levels.

Notes

1. Although we searched in breath and depth, we may not have included some important papers or reports on the subject. However, we are confident that the bulk of the relevant literature is analyzed in our survey.
2. Our survey is restricted to the literature studying firms' behavior.
3. Utility models -which are sometimes referred to as "petty patents" or "innovation patents"- are more adapted to incremental or minor innovations since they grant exclusive rights to inventions that lack some of the requirements needed for patents – such as novelty or non-obviousness. Hence, they could be better suited for small and medium-sized enterprises (SMEs) and/or innovators in developing countries.
4. The International Union for the Protection of New Varieties of Plants (UPOV) provides an international framework for the protection of new plant varieties.
5. According to Langlois (2001), codified knowledge is that which has been or can be converted into symbols for easy replication, transmission and storage, while tacit knowledge cannot be articulated explicitly, but must be acquired through learning processes over time.
6. See Basant (2004) for this argument applied to the Indian IT firms.
7. For instance, Hanel (2005) mentions that almost one-third of manufacturing firms that introduced an innovation in Canada between 1997 and 1999 did so without conducting any form of R&D.
8. Sometimes surveys inquire whether the innovation is new for the world, for the country or for the firm.
9. In the annex, information is presented about the data sources, methodology, period, and type and number of firms on which each of the surveyed studies is based.
10. Design complexity exists when a product is comprised of many components or sub-systems.
11. This study updates the results of a previous survey undertaken in 1989-91 in which it was found that trademarks were the most popular form of protection, followed by patents and trade secrets, industrial designs and copyrights (see Hanel, 2006).
12. Non-competition clauses imply that the employee agrees not to pursue a similar profession or trade in competition with the employer. They are included in labor contracts in order to prevent the employee, at the end of the contract, from working for another employee or starting a business taking advantage of the knowledge or trade secrets learned in the original job.
13. R&D intensive firms are those which spend more than 10 per cent of their sales revenues on R&D activities.
14. Although the implications of this finding should be further explored, it is relevant to mention that the authors found that patent officers attribute greater importance to patents than do R&D officers, which at least means that when analyzing this type of survey one should be aware of who are the respondents.
15. Availability is defined on the basis of the firms' answers regarding which mechanisms are available, or not, for them.
16. Strength is defined on the basis of the surveyed firms' perception on the effectiveness of each appropriation method.
17. Discrete products are those comprised of a relatively small number of patentable elements (e.g. drugs, chemicals). Complex products are those that are or can be protected by numerous patents (e.g. computers, communications equipment).
18. Not all studies define patent propensity in the same way. We mention below the definition adopted in each case.
19. Although we have not been able to find it, a pioneer study for Canada (De Melto *et a*l, 1980) quoted by Hanel (2006) is worth mentioning, in which it was found that patenting propensity was higher in larger firms as well as in foreign-owned ones.
20. A patent thicket is a situation in which a firm is required to obtain the licenses for using many other complementary technologies patented by other firms when this firm produces and sells a product or undertakes research.
21. Note that we are not analyzing the inverse relationship, that is, from patents to R&D. In this regard, some studies such as Arora *et al* (2003) found that patents stimulated R&D activities. However, the evidence on the impact of patents on innovation is still ambiguous (see Hall, forthcoming and Hanel, 2006).
22. According to a recent definition, open innovation is the use of purposive inflows and outflows of external knowledge to accelerate internal innovation and expand the markets for external use of innovation (Chesbrough, 2006).
23. López *et al* (2005), Pinto García (2005), Portilla (2005), Salles Filho *et al* (2006) and Corrales (2006).
24. The above-mentioned study by López and Orlicki (2007) showed that in Latin American countries when firms are asked about the obstacles for innovation activities, IPR issues rank clearly below others such as macro-economic and institutional instability, the high costs of innovation activities, market failures (such as lack of credit) and the small size of domestic markets.

References

Abernathy, W. and J. Utterback, 'A Dynamic Model of Process and Product Innovation', *Omega*, Vol. 3, N. 6, 1975.

Arrow, K., 'Economic Welfare and the Allocation of Resources for Invention', in *The Rate and Direction of Inventive Activity,* R. Nelson (ed.), Princeton University Press, Princeton, US, 1962.

Arundel, A., 'The Relative Effectiveness of Patents and Secrecy for Appropriation', *Research Policy*, Vol. 30: 611-624, 2001.

Arundel, A. and I. Kabla, 'What Percentage of Innovations are Patented? Empirical Estimates for European Firms', *Research Policy*, Vol. 27: 127-141, 1998.

Baldwin, R., G. Gellatly, J. Johnson and V. Peters, 'Innovation in Dynamic Service Industries', Statistics Canada, Ministry of Industry, 1998.

Basant, R., 'Intellectual Property and Innovation. Changing Perspectives in the Indian IT Industry', Strategies for Building Software Industries in Developing Countries Conference, Honolulu, 19-21 May, 2004.

Blind, K., J. Edler, R. Frietsch and U. Schmoch, 'Motives to Patent: Empirical Evidence from Germany', *Research Policy*, Vol. 30: 655-672, 2006.

Blind, K., J. Edler, U. Schmoch, B. Anderson, J. Howells, I. Miles, J. Roberts, L. Green, R. Evangelista and C. Hipp, 'Patents in the Service Industries – Final Report', *Fraunhofer Institut für Systemtechnik und Innovationsforschung*, Karlsruhe, 2003.

Brouwer, E. and A. Kleinknecht, 'Innovative Output, and a Firm's Propensity to Patent. An Exploration of CIS Micro Data', *Research Policy*, Vol. 28: 915-624, 1999.

Byma, J. and A. Leiponen, 'Can't Block, Must Run: Small Firms and Appropriability', *Working Paper Series* 1-07, The Mario Einaudi Center for International Studies, January 2007.

Chabchoub, N. and J. Niosi, 'Explaining the Propensity to Patent Computer Software', *Technovation*, Vol. 25: 971-978, 2005.

Chesbrough, M., 'Open Innovation: A New Paradigm for Understanding Industrial Innovation', in *Open Innovation: Researching a New Paradigm*, H. Chesbrough, W. Vanhaverbeke and J. West (eds.), Oxford University Press, 2006.

Cincera, M., 'Patents, R&D and Technological Spillovers at the Firm Level: Some Evidence from Econometric Count Models for Panel Data', *Journal of Applied Econometrics*, Vol. 12, N. 3, 1997.

Cohen, W., R. Nelson and J. Walsh, 'Protecting Their Intellectual Assets: Appropriability Conditions and Why US Manufacturing Firms Patent (or Not)', *Working Paper N. 7552,* National Bureau of Economic Research, Cambridge, US, 2000.

Cohen, W., A. Goto, A. Nagata, R. Nelson and J. Walsh, 'R&D Spillovers and the Incentives to Innovate in Japan and the United States', Working Paper, 2001.

Corrales, C., *Las Pequeñas y Medianas Empresas (PYME)* y *La Propiedad Intelectual: El Caso de Costa Rica*, prepared for WIPO, 2006.

Combe, E. and E. Pfister, 'Patents Against Imitators: An Empirical Investigation on French Data', *Cahiers de la MSE*, 2000.

Crepon, B. and E. Duguet, 'Innovation: Measurement, Returns and Competition', *INSEE Studies*, N. 1, 1996.

Davis, L. and K. Kjær, 'Patent Strategies of Small Danish High-Tech Firms', The DRUID Summer Conference, Copenhagen, Denmark, June 2003a.

Davis, L. and K. Kjær, 'Appropriability Strategies by Small Biotech Firms in Medicon Valley: Does Location in the Cluster Matter?', The DRUID Summer Conference, Copenhagen, Denmark, June 2003b.

Dahlander, H., 'Appropriating Returns from Open Innovation Processes: A Multiple Case Study of Small Firms in Open Source Software', mimeo, 2004.

De Melto, D., K. Mc Mullen and R. Willis, 'Innovation and Technological Change in Five Canadian Industries', *Discussion Paper N. 176,* Economic Council of Canada, Ottawa, 1980.

Dolfsma, W., 'The Process of New Service Development – Issues of Formalization and Appropriability', *International Journal of Innovation Management*, 8(3): 319-337, 2004.

Dosi, G., L. Marengo and C. Pasquali, 'How Much Should Society Fuel the Greed of Innovators? On the Relations between Appropriability, Opportunities and Rates of Innovation', *Research Policy* 35 (2006) 1110–1121, 2006.

Duguet, E. and I. Kabla, 'Appropriation Strategy and the Motivations to Use the Patent System: An Econometric Analysis at the Firm Level in French Manufacturing', *Annales d'Économie et Statistique*, N. 49/50, 1998.

Gallini, N. and S. Scotchmer, 'Intellectual Property: When is it the Best Incentive System?', in *Innovation Policy and the Economy*, A. Jaffe, J. Lerner and S. Stern (eds.), Vol. 2, MIT Press, 2002.

Giuri, P., M. Mariani, S. Brusoni, G. Crespi, D. Francoz, A. Gambardella, W. Garcia-Fontes, A. Geuna, R. Gonzales, D. Harhoff, K. Hoisl, C. Le Bas, A. Luzzi, L. Magazzini, L. Nesta, O. Nomaler, N. Palomeras, P. Patel, M. Romanelli and B. Verspagen, 'Inventors and Invention Processes in Europe: Results from the PatVal-EU Survey', *Research Policy 36 (2007),* 1107–1127, 2007.

González-Álvarez, N. and M. Nieto-Antolín, 'Appropriability of Innovation Results: An Empirical Study in Spanish Manufacturing Firms', *Technovation*, Vol. 27, pp. 280-295, 2007.

Gupta, V., 'Determinants of Incidence and Modes of Alliance: A Study of the Indian Information Technology Industry', PhD dissertation, Indian Institute of Management, India, 2004.

Hall, B.H. and R.H. Ziedonis, 'The Patent Paradox Revisited: An Empirical Study of Patenting in the US Semiconductor Industry, 1979-1995', *Journal of Economics*, Vol. 32, N. 1: 101-128, 2001.

Hall, B.H. (forthcoming), 'Patents', in *The New Palgrave Dictionary of Economics*, S.N. Durlauf and L.E. Blume (eds.), Second Edition, Palgrave Mac Millan, 2008.

Hanel, P., 'Current Intellectual Property Protection Practices of Manufacturing Firms in Canada' in *Intellectual Property and Innovation in the Knowledge–Based Economy*, J. Putnam (ed.), Industry Canada, 2005

Hanel, P., 'Intellectual Property Rights Business Management Practices: A Survey of the Literature', *Technovation*, Volume 26, N. 8, 2006.

Harabi, N., 'Appropriability of Technical Innovations. An Empirical Analysis', *Research Policy*, Vol. 24: 981-992, 1995.

Hipp, C.B. and C. Herstatt, 'Patterns of Innovation and Protection Activities within Service Companies. Results from a German Study on Service-Intensive Companies', *Working Paper N. 45,* Technische Universitat Hamburg-Harburg, 2006.

Hu, A.G. and G. Jefferson, 'A Great Wall of Patents: What is Behind China's Recent Patent Explosion?' mimeo, 2006.

Hurmelinna, P. and K. Puumalainen, 'The Dynamics of Appropriability Regimes', The DRUID Tenth Anniversary Summer Conference, Copenhagen, June 2005.

Hurmelinna, P. and K. Puumalainen, 'Nature and Dynamics of Appropriability: Strategies for Appropriating Returns on Innovation', *R&D Management*, Vol. 37, N. 2, 2007.

Hussinger, K., 'Is Silence Golden? Patent versus Secrecy at the Firm Level', *Discussion Paper N. 37,* Center for European Economic Research, 2005.

Jensen, P. and E. Webster, 'SMEs and Their Use of Intellectual Property Rights in Australia', *Working Paper N. 09/04*, Intellectual Property Research Institute of Australia, 2004.

Konig, H. and G. Licht, 'Patents, R&D, and Innovation', *ifo Studien Zeitschrift fur empirische Wirtschaftsforschung* 4/95, 521-43, 1995.

Kuusisto J. and S. Päällysaho, 'Intellectual Property Protection and Management in KIBS Businesses', Innovation Pressure Conference, Finland, March 2006.

Langlois, R.N., 'Knowledge, Consumption, and Endogenous Growth', *Journal of Evolutionary Economics* 11, 77–93, 2001.

Laursen, K. and A. Salter, 'My Precious – The Role of Appropriability Strategies in Shaping Innovative Performance', *Working Paper N. 05-02,* Danish Research Unit for Industrial Dynamics, 2005.

Levin, R.C., A.K. Klevorick, R.R. Nelson, S.G. Winter, R. Gilbert and Z. Griliches, 'Appropriating the Returns from Industrial Research and Development', *Brookings Papers on Economic Activity*, Vol. 1987, N. 3, Special Issue on Microeconomics, pp. 783-831, 1987.

Licht, G. and K. Zoz, 'Patents and R&D. An Econometric Investigation using Applications for German, European and US Patents by German Companies', *Annales d'Économie et Statistique*, N. 49/50, 1998.

López, A., G. Pupato and A. Sacroisky, *La Propiedad Intelectual en las Pequeñas y Medianas Empresas: el Caso Argentino*, WIPO, Geneva, 2005.

López, A. and E. Orlicki, *Innovación y mecanismos de apropiabilidad en el sector privado en América Latina*, WIPO-ECLAC Research Project, mimeo, 2007.

Mansfield, E., 'Patents and Innovation: An Empirical Study', *Management Science*, Vol. 32, No. 2: 173-181, 1986.

Mansfield, E., M. Schwartz and S. Wagner, 'Imitation Costs and Patents: An Empirical Study', *The Economic Journal*, Vol. 91, N. 364, 1981.

Mairesse, J. and Mohnen, P., 'Intellectual Property in Services. What Do We Learn from Innovation Surveys?' Patents Innovation and Economic Performance, 2003.

Nagaoka, S. and Y. Nishimura, 'An Empirical Assessment of the Effects of Patent Thickets', mimeo, 2006.

Nelson, R., 'The Simple Economics of Basic Scientific Research', *Journal of Political Economy*, V. 67, 297-306, 1959.

Pinto García, O.G., *La Propiedad Intelectual y Las Pequeñas y Medianas Empresas en Colombia*, prepared for WIPO, Bogotá, 2005.

Portilla, R., *Uso Actual del Sistema de Propiedad Intelectual por las Pequeñas y Medianas Empresas (PYMES) en Chile,* prepared for WIPO, Santiago de Chile, 2005.

Salles-Filho, S., S.P. de Carvalho, C. Ferreira, E. Pedro and M. Fuck, *Sistema de Propriedade Intelectual e as Pequenas e Médias Empresas no Brasil*, WIPO, Geneva, 2006.

Sattler, H., 'Appropriability of Product Innovations: An Empirical Analysis for Germany', *Research Papers on Marketing and Retailing* N. 003, University of Hamburg, 2003.

Scherer, F.M., S. Herzstein Jr., A. Dreyfoos, W. Whitney, O. Bachmann, C. Pesek, C. Scott, T. Kelly and J. Galvin, 'Patents and the Corporation: A Report on Industrial Technology under Changing Public Policy', Harvard University, Graduate School of Business Administration, Boston, US, 1959.

Schumpeter, J., *Capitalism, Socialism and Democracy*, Harper and Row, 1942.

Teece, D., 'Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy', *Research Policy*, 15: 285-305, 1986.

Thumm, N., 'Research and Patenting in Biotechnology: A Survey in Switzerland', Swiss Federal Institute of Intellectual Property, Publication, March 12, 2003.

Thumm, N., 'Strategic Patenting in Biotechnology', *Technology Analysis and Strategic Management*, 16:4, 529-538, 2004.

West, J., 'Does Appropriability Enable or Retard Open Innovation?' in *Open Innovation: Researching a New Paradigm*, H. Chesbrough, W. Vanhaverbeke and J. West (eds.), Oxford University Press, 2006.

West, J., W. Vanhaverbeke and H. Chesbrough, 'Open Innovation: A Research Agenda', in *Open Innovation: Researching a New Paradigm,* H. Chesbrough, W. Vanhaverbeke and J. West (eds.), Oxford University Press, 2006.

Annex 1. Summary of Reviewed Papers

Authors	Paper	Country	Period	Data source	Methodology	Type of firm	Number of firms
Arundel (2001)	The Relative Effectiveness of Patents and Secrecy for Appropriation	European countries	1993	CIS	Ordered logit regressions	R&D performing firms	2849
Arundel and Kabla (1998)	What Percentage of Innovations are Patented? Empirical Estimates for European Firms	European countries	1993	PACE survey and SESSI survey	Simple ordered logit model	Largest R&D performing industrial firms	604
Baldwin et al (1998)	Innovation in Dynamic Service Industries	Canada	1996	Statistics Canada's Survey of Innovation	Descriptive statistics	Firms from three sectors of the service economy: communications, financial services and technical business services	Communications firms (excluding postal services): 895; banks and trust companies and life insurers: 160 firms; businesses engaged in computer or related services, offices of engineers, and other technical services: 3,830
Basant (2004)	Intellectual Property and Innovation. Changing Perspectives in the Indian IT Industry	India	2004	Gupta, 2004	Descriptive statistics	IT firms	120
Blind et al (2003)	Patents in the Service Industries	European countries	1998-2000 and 2001	Second Community Innovation Survey	Descriptive statistics and case studies	Service firms	65
Blind et al (2006)	Motives to Patent: Empirical Evidence from Germany	Germany	2002	Questionnaire to German enterprises which had applied for a minimum number of three patents at the EPO in 1999	Factor analysis and multivariate probit analysis	Firms that in 1999 had applied for a minimum number of three patents	Over 500
Brouwer and Kleinknecht (1999)	Innovative Output, and a Firm's Propensity to Patent. An Exploration of CIS Micro Data	Netherlands	1992	Dutch part of the Community Innovation Survey (CIS)	Multivariate analysis	Firms with 10 and more workers in all manufacturing sectors	1,300
Byma and Leiponen (2007)	Can't Block, Must Run: Small Firms and Appropriability	Finland	2002-03	Survey data collected by ETLA	Simple probit and multinomial logit models	Small and medium-sized firms in all economic sectors except agriculture, finance, and real estate	312
Chabchoub and Niosi (2005)	Explaining the Propensity to Patent Computer Software	US and Canada	2000-02	Different databases providing financial information and the USPTO data on software patents	Logistic regression analysis and linear regression	Computer software-producing companies	Over 1,700
Cincera (1997)	Patents, R&D and International Spillovers at the Firm Level: Some Evidence from Econometric Count Models for Panel Data	European countries	1983-91	EPO database, Compustat (Standard and Poor's) and the firms' annual reports	Poisson, count panel data, GMM panel data	International manufacturing firms investing substantial amounts in R&D	181
Cohen et al (2000)	Protecting their Intellectual Assets: Appropriability Conditions and Why US manufacturing Firms Patent (or Not)	US	1994	Survey questionnaire to R&D managers	Factor analysis	Manufacturing firms that perform R&D with at least 5 million US$ in sales or more than 20 employees	1,165
Cohen et al (2001)	R&D Spillovers, Patents and the Incentives to Innovate in Japan and the United States	US and Japan	1994	Survey of managers of R&D units of manufacturing firms in the US and Japan	Weighted logistic regression	Manufacturing firms that perform R&D (US) and firms with capitalization over 1 billion yen conducting R&D in manufacturing industries (Japan) with annual sales of 50 million USD or above	826 (US) and 593 (Japan)
Combe and Pfister (2000)	Patents Against Imitators: An Empirical Investigation on French Data	France	1993	SESSI appropriation survey	Multinomial ordered logit models	Innovative manufacturing firms	950

Authors	Paper	Country	Period	Data source	Methodology	Type of firm	Number of firms
Dahlander (2004)	Appropriating Returns From Open Innovation Processes: A Multiple Case Study of Small Firms in Open Source Software	Sweden and Finland	2004	Annual reports, company directories, business and specialist press, homepages and semi-structured face-to-face interviews	Multiple case studies	Small firms that attempt to commercialize OSS and generate revenues	6
Davis and Kjær (2003a)	Patent Strategies of Small Danish High-Tech Firms	Denmark		Semi-structured interviews	Case study	Firms that employ between 5 and 250 people from three high-tech industries: telecommunications, software and (pharmaceutical-related) biotechnology	34
Davis and Kjær (2003b)	Appropriability Strategies by Small Biotech Firms in Medicon Valley: Does Location in the Cluster Matter?	Denmark		Interviews with small biotech firms in the greater Copenhagen area (Medicon Valley)	Case study	Small biotech firms	Over 100
Duguet and Kabla (1998)	Appropriation Strategy and the Motivations to use the Patent System: an Econometric Analysis at the Firm Level in French Manufacturing	France	1990-92	French survey on appropriation (EFAT), Research survey and EPAT	Two equations model estimated by asymptotic least squares	Firms that applied for at least one patent	299
Gonzalez-Alvarez and Nieto-Antolin (2007)	Appropriability of Innovation Results: An Empirical Study in Spanish Manufacturing Firms	Spain	2002	Questionnaire	Factorial analysis and regression analysis	Large or medium-sized manufacturing companies	258
Hall and Ziedonis (2001)	The Patent Paradox Revisited: An Empirical Study of Patenting in the United States Semiconductor Industry, 1979-1995	US	1979-95	Interviews	Poisson-based econometric models	Large and medium-sized semiconductor manufacturers engaged in both process and product innovation, and smaller design firms engaged primarily in product innovation	95
Hanel (2005)	Current Intellectual Property Protection Practices of Manufacturing Firms in Canada	Canada	1993-99	Statistics Canada's Survey of Innovation 1993 and 1999	Logit models	Manufacturing firms with at least 20 employees and a gross business income over 250,000 US$	5,220
Harabi (1995)	Appropriability of Technical Innovations. An Empirical Analysis.	Switzerland	1988	Survey to R&D executives from selected firms	Descriptive statistics	Firms actively engaged in R&D, from 127 different lines of business, mainly in the manufacturing sector	358
Hipp and Herstatt (2006)	Patterns of Innovation and Protection Activities within Service Companies. Results from a German Study on Service Intensive Companies	Germany	2004	Questionnaire	Probit model	Service-intensive firms	99
Hu and Jefferson (2006)	A Great Wall of Patents: What is Behind China's Recent Patent Explosion?	China	1995-2001	Survey of large and medium-sized enterprises by China's National Bureau of Statistics (NBS)	Zero Inflated Poisson (ZIP) model	Large and medium-sized industrial enterprises	Over 500
Hurmelinna and Puumalainen (2007)	The Dynamics of Appropriability Regimes	Finland	2004	Questionnaire	Linear regression analysis	Companies with at least 50 employees from several industrial sectors engaged in R&D	299
Hussinger (2005)	Is Silence Golden? Patents versus Secrecy at the Firm Level	Germany	1998-2000	Mannheim Innovation Panel (MIP) - German part of the Community Innovation Survey (CIS) of the European Commission	Factor analysis, tobit and probit models	Manufacturing firms that conducted R&D in the year 2000 and are product innovators	626
Jensen and Webster (2004)	SMEs and their Use of Intellectual Property Rights in Australia	Australia	1994-2001	Australian Bureau of Statistics (ABS), IP Australia and Australia OnDisc, IBISWorld Australia databases	OLS estimation method	Small and medium-sized firms	166
Jensen and Webster (2006)	Managing Knowledge Flows through Appropriation and Learning Strategies	Australia	2001-04	Melbourne Institute Business Survey 2001-04	SUR method	Manufacturing and service firms	over 600

Authors	Paper	Country	Period	Data source	Methodology	Type of firm	Number of firms
Levin et al (1987)	Appropriating the Returns from Industrial Research and Development Companies	US	1987	Questionnaire to R&D managers	Principal components analysis	R&D performing manufacturing firms	650
López and Orlicki (2007)	Innovación y mecanismos de apropiabilidad en el sector privado en América Latina	Argentina	1992-2001	Argentina's Innovation Survey 1992-96 and 1998-2001	Probit model and count data models	Innovative manufacturing firms	186
Mairesse and Mohnen (2003)	Intellectual Property in Services: What Do We Learn from Innovation Surveys?	France	1998-2000	French CIS3 survey	Correspondence analysis and clustering analysis	Manufacturing and services firms	1,914 service firms
Nagaoka and Nishimura (2006)	An Empirical Assessment of the Effects of Patent Thickets	Japan	2006	Survey of intellectual property-related activities of Japanese firms collected by the Japan Patent Office	OLS estimation	Manufacturing firms	611
Päällysaho and Kuusisto (2006)	Intellectual Property Protection and management in KIBS Businesses	Finland and UK	2005	Telephone survey	Descriptive statistics	Small businesses in three knowledge intensive and innovative sectors of KIBS services: (1) software consultancy and supply (2) business and management consultancy activities (3) advertising	300
Sattler (2002)	Appropriability of Product Innovations: An Empirical Analysis for Germany	Germany	1990-95	Mannheim Innovation Panel and telephone survey	Logistic regression analysis	Innovative firms	1,844
Thumm (2003)	Research and Patenting in Biotechnology. A Survey in Switzerland	Switzerland	2000-02	Swiss biotechnology industry survey	Descriptive statistics	Biotechnology firms	53
Thumm (2004)	Strategic Patenting in Biotechnology	Switzerland	2000-02	Swiss biotechnology industry survey	Descriptive statistics	Biotechnology firms	53

COMMENTS ON
INNOVATION AND APPROPRIABILITY: EMPIRICAL EVIDENCE AND RESEARCH AGENDA

DOMINIQUE FORAY*

As Suzanne Scotchmer wisely wrote some years ago (2004), many discussions of appropriability begin from the premise that IP protection is the solution to the problem. However, as she pointed out, it is better to start from the problem (i.e. the difficulty to capture the rent produced by an innovation and the incentive deficit that such difficulty can create) rather than starting from the solution. Andrés López must be congratulated for starting from the problem rather than the solution and thereby having written a very complete, timely and relevant paper on the topic of appropriability. In spite of the many empirical studies produced, evidence on the nature and strength of conditions for appropriability and on the working of the patent system is scattered and unsystematic; a situation already described by Levin *et al* in the late 1980s. As observed by López, the lack of evidence in the case of developing countries is even more worrying.

Appropriability: the Origin of a Concept

The dual properties of non-rival usage and costly exclusion of others from possession define what economists mean when they speak of pure public goods. While the term has become familiar, confusion lingers around its meaning and implications. It does not imply that such commodities cannot be privately supplied. It does not mean either that a government agency should or must produce them, nor does it identify "public goods" with *res publica*, the set of things that remain in "the public domain". What does follow from the nature of pure public goods is the proposition that competitive market processes will not do an efficient job of allocating resources for their production and distribution (Aghion *et al* (2008)). Where such markets yield efficient resource allocations, they do so because the incremental costs and benefits of using a commodity are assigned to the users. In the case of public goods, however, such assignments are not automatic and they are especially difficult to arrange under conditions of competition.

The disclosure of even a commodity's general nature and significance (let alone its exact specifications) to a purchaser engaging in a market transaction can yield valuable transactional spillovers to potential purchasers, who would remain free to then walk away. Complex provisions in the contracts and a considerable measure of trust are required for successfully "marketing an idea". Both of these are far from cost-free to arrange, especially in "arms-length negotiations" among parties that do not have symmetric access to all the pertinent information. Contracting for the creation of information goods, the specifications for which may be stipulated, but which do not yet exist is fraught with still greater risks; and, *a fortiori*, fundamental uncertainties surround transactional arrangements involving efforts to produce truly novel discoveries and inventions. This leads to the conclusion that the findings of scientific and technological research, being new information, could be seriously undervalued were they sold directly through perfectly competitive markets, and the latter would, therefore, fail to provide sufficient incentives to elicit a socially desirable level of investment in their production.

The above describes what has come to be referred to as the "appropriability problem", the existence of which is invoked in the mainstream economics literature as the primary rationale for

* Chair of Economics and Management of Innovation, Ecole Polytechnique Fédérale de Lausanne, Switzerland.
The views expressed in these comments are those of the author and do not necessarily represent those of WIPO.

government intervention by means of various public policy instruments. The recommended policy response to the diagnosis of a chronic condition of under-investment in scientific and technological research by the private sector is that the public sector should first act to increase R&D expenditures, using general tax revenues for that purpose. A number of principles are advanced as guidance for such interventions, some of which turn out to be less compelling than would appear at first sight.

Survey Data…

Regarding the empirical methods that have been used to grasp the issue of appropriability, one must observe that most of the evidence comes from a sequence of surveys (Yale, Carnegie, PACE, CIS and its extensions). Survey research is a difficult research tool (Cockburn, 1992). Data produced through a survey are not the sort of data economists are familiar with (such as simple reporting of objectives, quantifiable information, etc.). People responding to a survey are asked to provide their opinion about something. They are asked to estimate the magnitude of abstract constructs rather than report concrete, objective facts. As Cockburn (ibid.) rightly observed, magnitude estimation is very difficult for survey respondents and behavioral researchers often have very limited success in obtaining consistent responses to simple objective questions which elicit quantitative estimates of physical properties ("which of these colors is the most blue?"). Economists playing with such data have to bear in mind the inherent difficulties of survey data.

…and Survey Questions: What is the Problem?

The typical question we find in many surveys is about the "effectiveness" of patents as an appropriability mechanism. But what does this question mean exactly; what is the problem? Do we want to know about patent effectiveness as a tool to limit spillovers? Well, limiting spillovers is a second order objective; i.e. a solution to a more generic problem which is about securing the rent from innovation. Limiting spillovers might be an obvious way to solve the generic problem but there are other options; maximizing spillovers, for example, in order to set a standard advantageous to the innovator. In this case he/she freely reveals the innovation in order to benefit from its increased diffusion. There are, indeed, cases in which some mechanisms, while being very ineffective in limiting spillovers, are actually very effective in securing the rent from innovation. The best case is of course "lead time" to which I will return later but the so called Hirshleifer effect provides another example.

These various cases show that it is important to decouple the objective of limiting spillovers and the objective of securing rents from the innovation; the latter being the fundamental appropriability objective while the former is likely to serve this fundamental objective well in certain situations but not so well in others.

And because the right question is not about limiting spillovers but securing rents, the answer to the question about the effectiveness of patents and other IP tools will show, not surprisingly, strong and persistent variations across sectors.

Lead Time: What do We Know About it as an Appropriability Mechanism?

Lead time appears very often as the most valuable mechanism to ensure appropriability. Lead time is based on the fact that even if unrestricted copying eventually drives the price of the marginal copy to 0, this does not happen so rapidly. The process of copying takes time and the sup-

ply of copies cannot instantly undergo infinite expansion. This is why lead time can work as an appropriability mechanism: the possession of the first copy (i.e. being the innovator) is an asset that can command positive prices under competitive conditions (Boldrin and Levine (2002)). The price reflects the present value of the future flow of marginal utilities that subsequent copies will yield to impatient consumers, because the process takes time. In a fictional world of total absence of IPR and unrestricted copying, lead time would appear as the only way of allowing competitive equilibrium with positive "first copy" prices.

However, in spite of these sound theoretical foundations of lead time as an appropriability mechanism, lead time remains a poorly understood strategy. It is difficult to know by reading and analyzing surveys whether the positive assessment of lead time by respondents is a description of a fact (every innovator enjoys a lead-time situation) or is taken as an explicit (not a default) strategy.

Historically, the effectiveness of lead time as an appropriability mechanism was supported by bad copies: copies of copies naturally were priced lower, for errors in transcription are cumulative (Plant, 1934). Today, copies of copies are perfect since this process no longer involves their degradation. The process of copying still takes time. However, there is an increase of productive activities shifting to an area of instantaneous infinite expansion of copies (area of digital products). It would be very useful to discuss what all this evolution means for lead time as an appropriability mechanism.

Appropriability and the New Modes of Innovation

Has the problem changed in nature because of innovation in the mode of innovation? Three new aspects of the innovation process are likely to affect the way appropriability is used and the relative effectiveness of the various mechanisms:

(a) **Routinization:** innovation is becoming a crucial capability in the knowledge economy; it has replaced price as the name of the game in a number of important industries (Baumol (2002)). Managers try, therefore, to make innovative activities a regular and even ordinary component of the activities of the firm and thereby minimize the uncertainty of the process. They try to routinize innovation. An obvious way to routinize it (to contain the risk they face in their innovation rivalry) is by coordinating their innovative activity through means such as research joint ventures, or engaging in technical cooperation through innovation trading or by licensing of proprietary technology even to direct competitors.

(b) **Open Innovation:** firms need to go beyond their own R&D and find the best technologies wherever they exist, combining them into integrated solutions. Important facilitators are the adoption of open standards in different areas as well as of a policy allowing diffusion of their own knowledge in return for low-cost absorption of the knowledge of others.

(c) **Innovation through Recombination:** this new model involves assembling a large number of pre-existing pieces of knowledge. New institutions are, therefore, required to contain the potentially increasing transaction costs of innovative activities in such a model. For instance, patent pools provide a regularized transactional mechanism in place of the statutory property rule baseline which requires an individual bargain for each transaction. They serve, therefore, to regularize technology transactions (patent pools, cross-licensing).

We see, therefore, that in each of these circumstances the strategy of limiting spillovers is weakened because it is subsumed by a superior objective dealing which involves the creation of prop-

er organizational and institutional conditions to maximize innovative performances in the new context.

What about Appropriability and Innovation in Developing Countries?

It is not true that in the realm of innovation there is only one game in town, in the sense of innovating for global markets. There are such things as local needs and local markets which are not necessarily well served and may require enhanced incentives from the government. Incremental and cumulative innovations, which are mostly informal (i.e. without R&D) and developed in the traditional sectors, are, thus, central to the innovative performance of developing countries. Although mostly dealing with low-level technologies, these innovations are generating local spillovers and, ultimately, will impact on the productivity of a wide range of sectors in the local economy.

So, even if a country could benefit from plugging some of its activities in the global market, this should not preclude supporting locally oriented innovation, which can be critical for growth and social well-being. The question is, therefore, what are the appropriability mechanisms which are the most adapted to appropriate rents from these kinds of innovation? As is well argued in the paper by López, we know very little on this issue.

Finally, a key role of entrepreneurs in developing countries is about learning what a given country is good at producing (Hausmann and Rodrick (2002)). For a developing country, there is great social value to discovering the relevant specialization because this knowledge can orient the investments of other entrepreneurs and can account for the emergence of a persistent pattern of change. This is mainly due to the fact that in developing countries the production functions of all extant goods are typically not common knowledge.

However, the initial entrepreneur who makes the "discovery" can capture only a small part of the social value that this knowledge generates. Other entrepreneurs can quickly emulate such a discovery. Consequently, entrepreneurship of this type, generating learning of what can be produced, will be under-supplied. There is, clearly, an appropriability issue. If learning what a country is good at producing requires investment and the return on this investment cannot be fully appropriated, we have a problem of appropriation which is not likely to be solved with legal protection. Indeed, entrepreneurs in developing countries are trying out technologies that already exist abroad and their discovery can be that an existing good can be produced profitably in their own country; although such a discovery does not normally get such protection, whether it has a high social return or not.

What has just been described is likely to be the most severe appropriability problem to be solved in developing countries and government policies should probably not just involve IP protection to solve such a problem.

Notes

1 For Hirshleifer (1971), innovators are the only ones to have information on future changes in the price of certain inputs that their innovation is likely to cause. Before revealing their innovation, they are, therefore, in a position to speculate on these factors. In this case, the free diffusion of knowledge is highly desirable. This mechanism makes it possible to reconcile in the best possible way the preservation of private interests and the maximization of spillovers.

2 Typically, firms are required to license into the pool all patents covering technology of use in the industry. In exchange, pool members are permitted to use any other member's technology.

References

Aghion, P., P. David and D. Foray, 'Science, Technology and Innovation for Economic Growth', *Research Policy*, to be published in 2008.

Baumol, W., *The Free Market Innovation Machine*, Princeton University Press, 2002.

Boldrin, M. and D.K. Levine, 'The Case Against Intellectual Property', *American Economic Review, Papers and Proceedings,* 92 (2002), 209-212, 2002.

Cockburn, I., 'Measuring Appropriability: What Can We Learn from the Yale Survey?', International Seminar Technological Appropriation, Paris, 1992.

Hausmann, R. and D. Rodrik, 'Economic Development as Self-Discovery', *NBER Working Paper 8952,* National Bureau of Economic Research, 2002.

Hirshleifer, J., 'The Private and Social Value of Information and the Reward to Inventive Activity', *American Economic Review*, September 1971.

Levin, R., A. Klevorick, R. Nelson and S. Winter, 'Appropriating the Returns from Industrial R&D', *Brookings Papers on Economic Activity*, 3, 1987.

López, A., 'Innovation and Appropriability; Empirical Evidence and Research Agenda', this publication.

Plant, A., 'The Economic Aspects of Copyright in Books', *Economica*, May 1934.

Scotchmer, S., 'Innovation and Incentives', *MIT Press*, 2004.

COMMENTS ON
INNOVATION AND APPROPRIABILITY: EMPIRICAL EVIDENCE AND RESEARCH AGENDA

KEVIN URAMA*.

The paper by Professor López sets out to identify the determinants of the use of different appropriability strategies at both the firm and sectoral levels. It provides a brief conceptual framework for understanding the dynamics of innovation and appropriability; reviews empirical evidence on the subject focusing mainly on case studies in developed countries: provides a synthesis of the results including the strengths, weaknesses and limitations of the literature; suggests a research agenda for developing countries.

Set within the context of the dynamics of technological change in developed economies, it argues that the rate of innovation in a perfectly competitive market economy would be very low due to the fundamental problem of excludability and appropriability of knowledge. Knowledge is a semi-public good and hence exclusion is feasible but rarely or never perfect. Without suitable appropriability strategies, innovators (and inventors) would therefore not have any means of protecting the knowledge they generate. They may therefore not recoup the fixed costs of knowledge generation as competitors are free to imitate the innovation cheaply. Such market failures and allied externalities which create differences between the private and social marginal return to knowledge generation would therefore lead to an under-investment in innovative activities.

The paper therefore reviews different appropriability strategies that enable economic agents to enjoy temporary pseudo-monopolistic power over the knowledge that it generates in order to profit from its innovations and inventions. A number of appropriability strategies were reviewed, including IPR mechanisms such as patents, copyrights, trademarks, industrial designs, utility models, plant variety protection, etc., as well as exploitation of lead time, rapid learning, complementary manufacturing sales and services, secrecy, labor legislation, employment contracts and human resource management strategies, passwords, digital signatures, copy prevention mechanisms, etc. It argues that profits from innovation depend on the interaction between three groups of factors: appropriability regimes, complementary assets and the presence or absence of a dominant paradigm in the sector in which a firm operates.

The author's review of the literature shows that knowledge appropriation strategies differ by (1) firm characteristics such as size, innovative capabilities, type of products, etc; (2) knowledge-specific factors (i.e. tacit vs. codified); (3) technology -specific factors (product vs. process innovations, etc.); (4) industry-specific factors such as life-cycle stages, appropriability strategies, etc; (5) geographical location and the prevailing institutional and legal environments. Knowledge appropriation strategies are also not mutually exclusive. This presents a complex scenario of interactions between firm characteristics, industry characteristics, firm location, type of knowledge, appropriation strategy, etc. that precludes straightforward prescription of appropriate appropriability strategies across firm types and/or trans-sectoral, regional or international transfer of appropriability strategies.

The paper therefore recognizes that translating the theoretical and empirical analyses from developed to developing economies presents huge challenges. Developing countries are at different stages of economic development presenting diversities in industry and firm characteris-

* Director, African Technology Policy Studies Network (ATPS), Nairobi, Kenya. The views expressed in these comments are those of the author and do not necessarily represent those of WIPO.

tics and heterogeneous levels of technological capacities. This leads to very different innovation-appropriability dynamics. Yet, the potential benefits of reverse engineering have often led to the erroneous conclusion that developing countries ought to be (or even are) "imitators" of technologies/knowledge from the developed countries rather than "generators" of technologies and knowledge for development. Hence, current understanding of the genuine innovative capabilities and relevance of indigenous knowledge to development in the developing world is still very low. Current understanding of the suitable appropriability mechanisms for protecting indigenous technologies and knowledge generated in the developing countries have therefore remained weak. As rightly noted by the author, there is an almost total absence of rigorous evidence on innovation-appropriability mechanisms deployed by firms in developing countries.

Set within the premise above, the paper presents a systematic ranking of the perceived effectiveness of different appropriability methods as perceived by firms, the determinants of firms' perceptions about the effectiveness of each appropriability tool, determinants of firms' patent propensities, and the different appropriability strategies found in developed countries. The motives for using IPRs include: (1) making profits; (2) prevention of copying reputation; (3) patent blocking; (4) prevention of lawsuits; (5) reputation enhancement; (6) tool for negotiations; (7) blocking of the development of substitutes; (8) earnings from licenses, etc. Product innovations have a higher propensity to be patented than process innovations. Patent propensities for process and product innovations depend on firm size, the perceived effectiveness of the patents, and intensity of competition faced by the firm, firm ownership structure, skill requirements, level of R&D investments, and sectoral specificities. Large firms not only had a higher propensity to patent, but also obtained more patents than smaller firms. The paper finds that in developing countries, the level of research and development (R&D) expenditures, foreign direct investment, and firm size and type of industry were the main determinants of choice of appropriability strategies. However, the number of firms using patents was significantly lower, e.g. under 10 per cent in Latin American countries.

Overall, the main conclusions of the paper can be summarized as follows:

- Firms tend to apply appropriability strategies sequentially both in developed and developing countries.
- Lead times and secrecy seem to be the most relevant appropriability strategy for most sectors and innovation types.
- The propensity to patent increases with firm size with large firms showing more significant preference for patenting than SMEs.
- Although the perceived effectiveness of patents is relatively low, most firms apply it, albeit in conjunction with other appropriability strategies, often for reasons other than protection of innovations.
- Patents are more relevant for product innovation than for process innovation.
- SMEs that adopt aggressive patent strategies often do so, not for exploiting their innovations, but for licensing or selling their patents.

Based on these findings, the author recommends a number of relevant areas for further research on the subject. Some of the important research topics identified include:

- A study of the impact of legal and institutional frameworks on the nature, scope and enforcement of IPRs in developing countries. This study should be designed to gather international micro-databases on innovation activities, institutions and legal frameworks, appropriability strategies and other firms' characteristics that could have an impact on those strategies.

- A behavioral economics study of the motivations of the use of IPRs by firms in developing countries. This study should be designed to better understand both the economic and non-economic factors that motivate firms to use specific appropriability mechanisms in developing countries. The study should be comprehensive and transcend the standard neo-classical economic paradigms of firm behavior.
- A study of the innovation-appropriability dynamics in different types of firms in developing countries. This study should be designed to examine the interactions between different appropriability mechanisms and the impact of cooperation actions in innovation activities and choice of appropriability strategies in developing countries.
- A regional study of the relationships between R&D investments and the use of patents and other appropriability mechanisms in selected sectors including the small scale and service industries and agriculture.
- A baseline study to document the scope, strength and enforcement of IPR legislation and the dynamics of technological change in developing countries.

Overall, the paper presents a good review of the innovation-appropriability strategies in developed countries and identifies key areas for further research and policy interventions in developing countries. However, although the title of the paper suggests a focus on innovation and appropriability strategies in developing countries, very few studies in developing countries were reviewed. The limited empirical evidence reviewed shows that the innovation-appropriability dynamics in developing countries are very different from those of the developed countries. This underscores the need for home-grown research and policy intervention in this area in developing countries.