Paper to be presented at

DRUID15, Rome, June 15-17, 2015

(Coorganized with LUISS)

Used, blocking and sleeping patents: Empirical evidence from a large-scale inventor survey

Salvatore Torrisi
University of Bologna
Department of Managemwent
torrisi@unibo.it

Alfonso Gambardella
Bocconi University
Department of Management & Technology
alfonso.gambardella@unibocconi.it

Paola Giuri
University of Bologna
Department of Management
paola.giuri@unibo.it

Dietmar Harhoff
Ludwig-Maximilians-University and Max Planck Institute for Innovation and Competition
LMU Center for Advanced Management Studies
dietmar.harhoff@ip.mpg.de

Karin Hoisl
Max Planck Institute for Innovation and Competition and Ludwig-Maximilians-University
LMU Center for Advanced Management Studies
hoisl@bwl.lmu.de

Abstract

This paper employs data from a large-scale survey (PatVal2) of inventors in Europe, the USA and Japan who were listed in patent applications filed at the European Patent Office with priority years between 2003 and 2005. We provide evidence about the reasons for patenting and the ways in which patents are being utilized. A substantial share of patents is not being used internally or for market transactions, which confirms the importance of strategic patenting. We investigate different types of unused patents ? unused blocking patents and sleeping patents. We also examine the association between used and unused patents and their characteristics such as family size, scope, generality and overlapping claims, technology area (complexity and concentration), type of applicant (firm size and the size of the firm?s patent portfolio), and the competitive environment where these patents originate (presence of one or more parties competing for the same patent). We discuss our results and derive an agenda for future research on innovation and patent policy.

Jelcodes:M21,L21

Used, blocking and sleeping patents: Empirical evidence from a large-scale inventor survey

1. Introduction

This paper focuses on comparisons between used and unused patents. We contribute to the literature on the economics and management of patents by addressing a number of salient research questions. We study various characteristics of used and unused patents. We further explore the differences between patents that remain unused for strategic reasons (e.g., patents that create a fence to prevent others from patenting similar inventions) and patents that are not used for other (non-strategic) reasons, such as low commercial value or the difficulty to transfer the technology to third parties in the market for technology (e.g., sleeping patents). We also analyze how the incidence of different types of unused patents varies across technological fields and firms of different size and patenting activity.

Understanding the characteristics of unused patents, the association between different types of unused patents and the context where these patents originate is important for various reasons. First, the explosion of patent applications at the European Patent Office (EPO) and the US Patent and Trademark Office (USPTO) raises concerns about the quality of applications and their effects on subsequent innovations and product market competition. Patent applications at the EPO grew from 197,539 in 2005 to 257,744 in 2012[1], and USPTO applications rose from 390,733 in 2005 to 542,815 in 2012[2]. The growth in patent filings is at odds with survey responses from R&D managers who typically portray patents as a comparatively weak instrument for protecting innovation (Levin et al., 1987; Cohen et al., 2000; Arundel, 2001). Moreover, there is empirical evidence that most patents do not generate any substantial economic value to their owners (Schankerman and Pakes, 1986; Harhoff et al. 1999; Scherer and Harhoff, 2000; Gambardella et al. 2008). While this may be due to *ex ante* uncertainty about patent value, there are also studies which suggest that a substantial number of patents are filed for purely strategic reasons (Hall and Ziedonis, 2001; Grindley and Teece, 1997) rather than protecting significant inventions.

This body of evidence casts doubts on the value of patents as an incentive for R&D and innovation. To some observers patents have become instruments of maintaining market power and reducing competition (Bessen and Meurer, 2008; Boldrin and Levine, 2013). Strategic patenting, which is particularly important in cumulative technologies like semiconductors, software, and

[1] See http://www.epo.org/about-us/annual-reports-statistics/statistics/filings_de.html, accessed on February 18, 2014.
[2] See http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm, accessed on February 18, 2014.

business methods, is often characterized by legal uncertainty and may lead to inefficient litigation (Harhoff and Reitzig, 2004; Hall et al., 2009). However, as Schankerman (2013) notes, although there is evidence of some blocking effect in US patents "More empirical work is needed to unbundle the effects of patents on downstream innovators and to confirm the results in other countries" (p. 479).

Second, the evidence on how patents are actually used is very limited. Though existing studies have addressed the issues of the use and relevance of patents, so far they have not provided exhaustive comparative evidence for different countries, technologies and firms of different size. Earlier surveys on inventions and patents typically focused on one or a few countries – e.g., Levin et al. (1987), Cohen et al. (2000), Scherer and Harhoff (2000), Harhoff et al. (2003), Zuniga and Guellec (2009), Nagaoka and Walsh (2009a), and Kani and Motohashi (2012) – or, like the Community Innovation Surveys (CIS), cover innovative activities in Europe, but do not account for the motives and use of patented inventions. Moreover, surveys on R&D performing firms (e.g., Arundel, 2001) do not reveal the reasons for patenting or the actual use of patents, which could help understand their economic relevance. One of the few systematic studies was the PatVal1 survey on European inventions, which found that about 36% of granted patents were not used by their owners either for commercial and industrial applications or for licensing (Giuri et al., 2007). Similarly, in both the U.S. and Japan the share of unused triadic patents is 38% (Nagaoka and Walsh, 2009b).

Third, patents may remain unused for strategic reasons such as to prevent the entry of new competitors. As Gilbert and Newbery (1983) pointed out, the monopolist may decide to patent even if its incentive to innovate is weakened by the 'replacement' effect and it will not use the patent (Gilbert and Newbery, 1983). Patents that are held to serve the function of bargaining chips in cross-licensing negotiations or infringement suits may also remain unused until an agreement is reached - such as cross-licensing which would lead to a termination of litigation. In industries characterized by cumulative technical change and complex products, patent thickets (a dense set of overlapping patent rights) lead firms to accumulate large patent portfolios to acquire bargaining power and to moderate the risk of being held up by the owners of blocking patents (Shapiro, 2001; Hall and Ziedonis 2001; Heller and Eisenberg, 1998). Patent portfolio races in which all competitors try to acquire as many patents as possible propagate the patent thicket and do not favor technology transactions such as licensing and cross-licensing, especially when patent rights are very fragmented (Siebert and von Graevenitz, 2008). Our data show that many unused patent rights are intended to block other parties; hence, they may hamper subsequent innovations. While unused patents in general may imply a socially wasteful use of R&D and IPR resources, unused blocking patents may also have anticompetitive implications "if the main aim and effect of strategic use of the patent system is to decrease the efficiency of rival firms' production" (Harhoff et al 2007: 6). Hence, it is important for policy reasons to distinguish between sleeping and blocking patents, and to examine their characteristics and correlates.

In conclusion, we still lack a good understanding of the extent to which patented innovations are not exploited and the reasons for the non-exploitation. At the same time, there is little empirical analysis that compares used and unused patents. There is also a limited understanding of the characteristics of unused patents, and particularly the differences between patents unused for strategic reasons and patents remaining unexploited for other reasons.

This paper contributes to the literature on the economic utilization of property rights by analyzing different modes of use of patents. The first type is strategic use – exemplified by patent applications seeking to prevent others from patenting similar inventions (blocking patents) and used either internally in new products or processes or externally through licensing, sale and spinoffs. The second type is commercial use - patent applications which have been filed for reasons other than blocking other parties (e.g., prevention of imitation) and used commercially. The third one is strategic non-use - blocking patent applications that are not used, but that may give their holders freedom to operate beyond the product and technology space already occupied. Finally, the fourth type is sleeping patents - patent applications filed for reasons different from blocking other parties and not used, neither internally nor externally. Moreover, we focus on three classes of correlates of patent uses: (i) the characteristics of the technological environment – technological complexity and competition; (ii) the patent value - measured by ex-ante observables like patent family size, number of claims, and oppositions; and (iii) legal validity – measured by overlapping references to prior art.

While earlier studies have investigated the implications of some of these variables for the accumulation of patent portfolios (Hall and Ziedonis, 2001), R&D expenditures and market value (Noel and Schankerman, 2013), the implications for patent use are much less explored. Moreover, an important novelty of this paper is that we separate empirically strategic patents that are also commercially used from strategic patents that are not used commercially. Similarly, we can identify patents which are merely sleeping, i.e., not performing any function and simply dormant by the applicants. The literature on strategic patenting and patent use more generally have not been able to draw this distinction empirically. As a result, this is one of the first papers to analyze the phenomenon and discuss relevant policy implications. Clearly, the problem of unused strategic patents is more serious, from a social point of view, than strategic patents that are in any case exploited commercially. Moreover, we can analyze the role of sleeping patents, which are simply left dormant. Because they do not carry any strategic value, actions that try to encourage their use may be more effective as companies will not oppose their exploitation.

Our paper contributes to public policy by proving a better understanding of the mechanisms underlying the motivations for patenting and the characteristics of used and unused patents. We use data on inventions as described in 22,567 patent applications, collected through the PatVal2 survey conducted between 2009 and 2011. We provide new evidence about the use of patented inventions and the reasons for patenting. The survey focused on patent applications filed at the EPO with priority dates between 2003 and 2005. The questionnaire was directed to inventors resident in 20 EU countries, Israel, the US and Japan. The data allow for comparisons across firms of different size and patenting activity, industries, and geographical areas.

Our empirical setting is ideal to investigate patent use since we focus on patents rather than firms' patenting strategy in general. This moderates the unobserved heterogeneity problems that are typical of studies whose unit of analysis is the firm or the industry. Moreover, it allows a deeper exploration of the motivations for patenting and the detailed patent and technological characteristics associated with the use of invented patents, while controlling for patent owner's characteristics like firm size and patent portfolio size.

The paper is organized as follows. Section 2 presents the conceptual background and the main research questions. Section 3 illustrates the dataset and the main variables. Section 4 shows the results and Section 4 concludes.

2. Conceptual background and research questions

To identify patenting strategies we look at the motives (reasons) for patenting and modes of actual patent use. We investigate the importance of different reasons for filing a patent application and focus on blocking patents, i.e., preventing others from patenting similar inventions. Moreover, we examine different types of use: *internal use* (in new products, services or processes) and *external use* (licensing to independent parties, sale and creation of a new firm).

By combining "blocking patents" as an important reason for patenting and (either internal or external) "use" of the patent, we delineate four types of patenting strategies as illustrated in Table 1: (a) strategic use – these are patent applications blocking other parties, but which are used internally or externally by the patent holder; (b) commercial use – these patent applications or grants were not filed with the intention of blocking other parties and are used either internally or externally; (c) strategic non-use - this type of strategy involves blocking patent applications that remain unused; (d) and sleeping patents which denote patents filed for reasons different from blocking other parties and which are not being used. As noted in the introduction, our ability to distinguish between these four categories of patents is an important novel aspect of our analysis compared to extant literature.

The notion of *strategic use* builds on blocking as a reason for patenting. Like patents taken out to prevent litigation and avoid being blocked by others, blocking patents may be used as a bargaining chip in cross-licensing deals or as a means of acquiring bargaining power for future legal disputes ('blocking to play'). However, only very few blocking patents are actually used in licensing and cross-licensing. As we will show, the latter account for a small share of patent uses. A large number of blocking patent applications are probably filed to protect inventions used commercially or are not used commercially. The latter are often referred to as 'blocking to fence' patents (Cohen et al. 2002) and correspond to our notion of *strategic non-use*. *Sleeping patents* remain unused for nonstrategic reasons, such as the difficulty of turning the invention into a commercial application or the inability to find a party interested in licensing or buying the patent right.

Table 1 about here

The literature has tried to predict particular modes of using patent (e.g., licensing) by looking at observable correlates of the owner's incentives or his ability to use a patent: a) characteristics of the patented technology (uncertainty, maturity or distance from commercial applications; complexity and concentration of the main technological fields); b) patent value (measured by forward citations or other indicators); c) characteristics of the patent holder (e.g., patent portfolio size, core business and complementary assets) and the competitive environment (e.g., the intensity of competition). Drawing on the literature regarding the economics and management of patents, we analyze a series of factors that should be associated with the four categories of utilizing patents. More precisely, we analyze various characteristics specific to the patent (family size, scope, generality, overlapping claims and oppositions received), the technology area (complexity and concentration), the applicant (firm size and the size of the firm's patent portfolio), and the competitive environment where patents originate (presence of one or more parties competing for the same patent).

Our analysis is explorative. We do not test specific hypotheses; instead, we present descriptive evidence that sheds light on some of the aforementioned research questions. Given the paucity of available data on the object of our analysis, we believe that this approach can offer useful insights into the conditions underlying used and unused patents.

Technological complexity

The transaction-oriented view on IPR posits that intellectual property reduces transaction costs in the market for products (Arora and Merges, 2004). Moreover, patents are a right that reduces transaction costs in the market for information by facilitating the trade of technology and other intangible assets (Arrow, 1962; Arora, Fosfuri and Gambardella, 2001; Arora and Merges, 2004).

However, patents also have a negative impact on use: by granting a monopoly on inventions they restrict use and increase price. Moreover, the patent owner may find it difficult or not convenient to exploit the invention for lack of complementary assets, strategic reasons (e.g., to avoid the entry of new competitors) and bargaining inefficiencies (the difficulty to find and negotiate with a potential acquirer). The exploitation of IPR assets may be hampered especially when too many property rights of small scale (and scope) are granted to several parties: "The tragedy of the anti-commons refers to the more complex obstacles that arise when a user needs access to multiple patented inputs to create a single useful product. Each upstream patent allows its owner to set up another toll-booth on the road to product development, adding to the cost and slowing the pace of downstream biomedical innovation" (Heller and Eisenberg, 1998: 699). Complex product industries like telecommunications, semiconductors and software are characterized by strong complementarities among technologies held by different owners. Firms in these industries then are possibly trapped in 'patent thickets', i.e. "a dense web of overlapping patents" (Shapiro 2001) to develop their products. The presence of thickets increases the risk of hold-up and raises bargaining costs. Instead, in discrete product industries (like chemicals and pharmaceuticals), a limited set of patents are required to commercialize a product. Previous work has studied the impact of complexity on patenting (e.g. Hall and Ziedonis, 2001; Graevenitz et al., 2013). Less known is the relationship between technological complexity and patent use (e.g., Cohen et al. 2002; Grindley and Teece, 1997).

High transaction costs affect the direct use of a patent in a new product - complexity implies that an innovator needs to gain "freedom to operate" by gaining access to complementary technologies patented by others. Technological complexity then spurs firms to accumulate blocking patents that could be used as a bargaining chip in litigation and cross-licensing (*strategic use*). Even if some blocking patents will be used in cross-licensing, these coordination mechanisms are inefficient in the presence of large patent thickets, and therefore subject to a high risk of bargaining failure (Siebert & von Graevenitz, 2008). In discrete product industries, blocking patents may be used to fence, that is to protect other patents and therefore as "substitutes for core inventions in order to maintain exclusivity over the technology" (Cohen et al. 2002: 1361). Thus, *strategic non-use* should be more likely for patents that protect discrete technologies like pharmaceuticals.

Intensity of competition

Technological competition implies that a large number of firms patent in the same technological area. It is worth note that technological complexity and competition are two distinct dimensions of the technological environment. A large number of patents and patent holders do not necessarily entail high complexity if overlapping claims are not very frequent. For example, the average number of overlapping claims among patents held by different firms in pharmaceuticals cosmetics (a measure of complexity developed by von Graevenitz et al, 2013) is about 3.62 against 62.39 in semiconductors and 102.65 in telecommunications, although the number of EPO patent applications in the former technology class is substantially larger[3]. Moreover, von Graevenitz et al. (2013) find a low correlation between their measure of technological complexity and competition measured by the technological fragmentation index developed by Ziedonis (2004).

Competition has been primarily studied to predict the impact on patenting. For example, Ziedonis (2004) finds a positive association between fragmentation of property rights (as a proxy for competition) and aggressive patenting by firms that try to avoid the risk of being fenced by the owner of earlier patents. Noel and Schankerman (2013) also find that the intensity of competition has positive effects on patenting of software firms. Much less explored (and probably more difficult to predict) is the association between technological competition and patent use. On the one hand, a large number of competitors increases the risk of being held-up by owners of blocking patents. Moreover, fragmentation of patent rights makes licensing and cross licensing quite difficult because of high transaction costs (Siebert & von Graevenitz, 2008). This spurs firms to accumulate patents for purely strategic reasons (blocking, prevention of litigation etc.), a large share of which are likely not to be used commercially. Thus, competition may lead to hold blocking patents used to ‘fence’, that is to create a barrier to protect patented inventions from similar substitute or complement inventions (*strategic non-use*). On the other hand, the presence of many parties that compete in the same technological area may increase the likelihood of licensing (therefore increase *strategic use* and decrease *strategic non-use*) for two reasons. First, even if licensing allows entry of new competitors thus generating a rent dissipation effect for incumbents, coordination among a large number of competitors to reduce new entry is difficult. Second, the first patent owner who license will enjoy a positive revenue effect, while the followers will only suffer a negative rent-dissipation effect (Arora et al. 2001). Because of these contrasting forces, the relationship between competition and patent use is quite difficult to predict. Moreover, technological competition should prompt a

[3] The number of EPO applications in 2004-2013 in pharmaceuticals is 61,962 (about 4.4% of total applications) against about 32,110 (about 2.3%) in semiconductors and 51,567 (3.9%) in telecommunications (http://www.epo.org).

more efficient use of patents that are not taken for blocking reasons, for example by spurring firms to get patented inventions faster to the market and thus it should be negatively correlated with the likelihood of *sleeping patents*.

Patent value

There is substantial empirical evidence that most patents do not generate any substantial economic value to their owners (Shankerman and Pakes, 1986; Harhoff et al. 1999; Gambardella et al. 2008). This is more likely to occur to the owners of large patent portfolios; many of them do not carry out any technology audit and therefore are unable to recognize and fully exploit the economic value of all their patents (Rivette and Kline, 2000).

As mentioned before, in complex product industries, firms have a strong incentive to increase the size of their patent portfolio and this goal is often attained at the cost of low value and uncertain legal validity of individual patents. Firms in these industries engage patent races to acquire the "freedom to operate" and to use patents as a bargaining chip in litigation or cross-licensing deals.

Controlling for complexity and other characteristics of the technological environment, the literature has found that the size of patent family (i.e., the number of different incarnations of the invention in different national patent systems) and forward citations are correlated with the economic (private) value of inventions (Harhoff et al 1999; Harhoff et al. 2003; Hall et al. 2005; Hall et al. 2009). Another measure used in the literature is the number of claims, although the economic interpretation of this variable is quite controversial. It is unclear whether they indicate patent complexity (Harhoff and Reitzig, 2004) or potential profitability (Lanjouw and Schankerman, 2004). Most likely, claims are a combination of both. Other patent characteristics such as generality and originality (Hall et al. 2001) are also likely to affect the economic value of patented inventions.

Higher value patents are more likely to be incorporated in new products, licensed or used to establish new ventures (*strategic use* and *commercial use*). For instance, a large patent family may signal the patent owner's expectation of opportunities to use the patent in different markets. By the same token, patents that protect general-purpose technologies have higher opportunities to be used in a large number of different applications (either internal or external use) as compared with patents protecting specific technologies.

Legal validity

The legal validity of a patent, which is not necessarily correlated with value, can affect use. A large number of references (backward citations) may reveal that an invention is more derivative in nature and, therefore, of limited importance (Lanjouw and Schankerman 2004). However, a large number of backward citations may also indicate a novel combination of existing ideas. This is probably the reason why Harhoff et al. (1999) have found that backward citations are positively correlated with patent value. A more precise indicator is provided by the number of X-type and Y-type citations that are references to prior art potentially challenging the novelty claims of the patent. The number of X and Y references measure the degree of overlapping claims with earlier patents. Overlapping claims measure the inventive step above a competitor's patents and thus a large number of overlapping claims indicate controversial patents, i.e., patents of uncertain validity. Earlier studies have found that patents with several overlapping claims with earlier patents are more likely to receive an opposition, although oppositions are also associated with measures of patent value like number of designated countries and forward citations (Harhoff and Reitzig, 2004; Hall et al., 2009).

Whatever the interpretation of oppositions or litigation, the presence of X and Y references signal that the use of a patent may be constrained by a high risk of legal disputes. Our empirical analysis aims to see the relationship between overlapping claims and the likelihood of use. We also see how X and Y references, as a proxy of legal validity, correlate with *strategic non-use* and *sleeping patents* respectively.

3. Data and methodology

3.1. The PatVal2 survey

The PatVal2 survey was undertaken as part of a project sponsored by the European Commission.[4] Within this project, we collected primary data with a self-administered survey of inventors located in 20 European countries (Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, UK, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Sweden, and Slovenia), Israel, the U.S., and Japan.[5] The survey examines multiple key dimensions of the inventive process, including the origin of new ideas, the organization and sources of inventive activities, the reasons for patenting and the use of patents. Moreover, compared to previous innovation and patent surveys, PatVal2 provides a broad international coverage of the antecedents and uses of patented inventions.

This section summarizes the sampling and data collection procedures that we employed. Our sampling unit (as well as unit of analysis) is the EP patent application.

---

[4] The InnoS&T project (EU FP7 collaborative project grant No. 217299 - "Innovative S&T indicators combining patent data and surveys: Empirical models and policy analyses") combined conceptual and data collection efforts.

[5] To facilitate the data collection in the U.S. and in Japan, the original group of European scholars acted jointly with local researchers from well-known research organizations and universities. In the U.S., we worked together with Eric von Hippel from Massachusetts Institute of Technology (MIT), Boston. In Japan, we collaborated with Sadao Nagaoka from the Research Institute of Economy, Trade and Industry (RIETI) and Hitotsubashi University, Tokyo.

We used the EPASYS database (as of 04/2008) to draw the sample of patent applications. Specifically, we collected all applications to the EPO with priority dates between 2003 and 2005, which listed inventors living in any of the 23 countries. After sampling the respective patent applications we randomly chose the addressee of the survey among the inventors listed on each patent. The sampling procedure resulted in 124,134 unique patent/inventor combinations (a more detailed description of the sampling strategy is available upon request from the authors).

In Europe and Israel, the full-scale survey took place between November 2009 and February 2010. In Japan, the full-scale survey started in October 2010 and closed at the end of July 2011. In the US, the full-scale survey took place between December 2010 and October 2011.

We received a total of 22,557 responses. 11,307 letters were returned due to wrong addresses or because the inventor(s) had deceased, 12 errors occurred while inventors filled out the online questionnaire, yielding a response rate of 20.0%. After we collected the data, we computed and employed sampling weights[6] for the multivariate analysis to ensure that our results are representative for the population of EP patents in the selected countries and years.

A concern with our survey may be that inventors are not sufficiently informed about firms' patent strategies that are typically decided by their employers. We argue, however, that most inventors do have the information that we asked for, particularly the information concerning the use and economic success of the inventions. This is because, for example, reward systems that inventors are interested in and benefit from, are tied to the economic exploitability of patented inventions (Harhoff and Hoisl 2007). Moreover, following Jung and Walsh (2014), we compared the shares of "don't know" answers on questions concerning the motives of patenting and the uses of patents between small and large firms. Unlike Jung and Walsh (2014), we do not find that the probability of non-response increases systematically with firm size.

Bibliographical and procedural information on the patents in our sample was supplemented from the PATSTAT database as of 04/2011

3.2. Variables and method

[6] The sampling weights were generated to account for both, coverage biases (non-random selection) and nonresponse biases. To account for coverage biases we calculated a set of weights which includes the inverse of the probability of a patent in the population being selected into the survey. To account for non-response biases we calculated a second set of weights which contains the inverse of the probability of a response conditional on being surveyed. The following variables were used to predict both, the selection into the survey and non-response: forward citations (within 5 years from the publication of the search report), patent family size, total number of ECLA technology classes, the number of inventors, patent main technology areas (6 macro technology areas), priority year, and country dummies. The total sampling weights were obtained by multiplying the two sets of weights.

Reasons for patenting

Table 2 illustrates the average importance of different reasons for patenting, on a Likert scale varying from 1 (not important) to 5 (very important), at the time of the patent application. Prevention of imitation and commercial exploitation are the most important reasons for patenting. Blocking competitors and pure defense have a median importance score of 4. (Cross-)licensing, reputation and the prevention of infringement suits are less important exhibiting a median importance of 3. Technical standards has median score of 1, which is lower than all the other reasons for patenting, suggesting that it is relatively rare for a patent to provide a protection for an invention embodied in technical standards. On the other hand, technical standards relatively often shape the opportunities or constraints for an invention. This is confirmed by a further question posed in the PatVal2 questionnaire that asked whether the surveyed invention utilizes or builds upon technical standards. Inventors report that this is the case for 20% of patents in the sample.

Results show that the importance of different reasons for patenting varies among countries. Almost all reasons for patenting, and in particular cross-licensing and blocking patents, are more important in Japan than in Europe/Israel and the U.S, with the only exception of reputation that is less important in Japan compared to the other countries. These differences (based on a test comparing the means of the variables) are statistically significant at the 1% or 5% level. The only exception is technical standards as a reason for filing a patent, which does not show statistically significant differences across countries.

We do not find, instead, large differences across technological areas. In line with previous results, cross-licensing is most important in electrical engineering and instruments. Cohen et al. (2000) and Cohen et al. (2002), for instance, found that in complex industries one of the most important reasons for patenting is the use of patents in negotiations (including cross-licensing negotiations). Moreover, based on the PatVal1 data, Giuri and Torrisi (2010) found that cross-licensing is a much more important motivation for patenting in complex product industries than in other industries. Blocking competitors as a reason for patenting is most important in consumption and construction.

Finally, the importance of the reasons for patenting varies with firm size: licensing is less important for large firms compared to small and medium sized firms. Pure defense is more relevant for large firms and for medium sized firms than for small firms. Differences are statistically significant at 1% level.

Table 2 about here

Uses of the patents

The value of an invention depends on the returns that it generates, which, in turn, rests on the ability to exploit it to develop new process or product applications or to transfer the patented technology to third parties through licensing, sale, etc. Properly deployed patents can translate into category-leading products, enhanced market share, and high margins (Rivette and Kline, 2000). However, most patents do not generate any substantial value to their owners (Shankerman and Pakes, 1986; Harhoff et al., 1999; Scherer and Harhoff, 2000; Gambardella et al., 2008). Many patents are not used at all (Giuri et al., 2007; Gambardella et al., 2007) or are used for strategic motives like blocking competitors (Cohen et al., 2000), gaining power in negotiations with partners in cross-licensing agreements (Hall and Ziedonis, 2001).

Table 3 reports the frequency of the following actual patent uses: commercial use, patent sale, patent licensing, cross-licensing, and creation of a new firm at the time of the survey[7]. It also shows the share of used patents and the share of blocking patents. A used patent is a patent that was used for any of the types of uses displayed in Table 3. A blocking patent is a patent for which blocking competitors was an important reason for patenting (score of 4 or 5 to blocking competitor as a reason for patenting).

Table 3 about here

Commercialization represents by far the most frequent patent use (55%), followed by licensing (7%), new firm creation (4%), and patent sale (4%). Only 1% of patents are used in cross-licensing agreements. In total, 58% of the patents are used for any of these purposes; 66% of the patents were filed to block competitors.

A typical source of inefficiency particularly important for technology markets is represented by transaction costs. Scholars argue that the patent system spurs excessive fragmentation of property rights, favors protection of low value inventions, which are sought for pure strategic reasons, and increases transaction costs in the market for technology (Hall and Ziedonis, 2001; Heller and Eisenberg, 1998). A share of the increasingly large number of applications is probably accounted for by low value patents that are neither used commercially nor transferred to third parties. This is more likely to occur to the owners of large patent portfolios; many of them do not carry out any technology audit and therefore are unable to recognize and fully exploit the economic value of all their patents (Rivette and Kline, 2000).

---

[7] Since there may be multiple uses of the patent (e.g. commercial use and licensing, licensing and new firm, etc.), for the sake of simplicity in Table 3 we only show the total share of patents in each of the uses, without reporting the single uses and the combination of uses. This information is available from the authors.

PatVal2 asks about patent sale. So far, the literature on technology markets has mainly focused on licensing and cross-licensing agreements whereas only few studies have examined patent sales (Lamoreaux and Sokoloff, 1997; Serrano, 2008). In particular, Serrano (2008) analyzed the incentives to sell a patent and found that the main drivers of this decision are the initial misallocation of patent rights and the importance of residual control rights in the market for patents. A patent holder with limited complementary assets needed to develop and commercialize an invention may gain from trading the patent right with another party that has a comparative advantage in these activities. Serrano (2008) also notes that the buyer may prefer to acquire the ownership of the patent to buying a license because ownership guarantees a higher degree of control of residual control rights. However, our data shows that patent sale is a quite rare event compared with other uses.

Another rare use of patents is the creation of a new firm (Wallin and Lindholm-Dahlstrand, 2006; Thornhill and Amit, 2001; Richardson, 1972; Chandy and Tellis, 1998). Table 3 shows that new firms are an equally rare event as patent sale.

There are differences across technologies in the use of patents. Patents are intensively used for commercial purposes in process engineering (62%) and consumption and construction (68%). Licensing is more frequent in these two technologies, as well. In line with earlier studies, cross-licensing occurs most frequently in electrical engineering, confirming that the use of the market for technology is also spurred by technological cumulativeness and product complexity (Cohen et al 2000; Giuri and Torrisi, 2010; Scotchmer, 1991).

In chemicals and pharmaceuticals nearly half of the patents remain unused. At the same time, the share of blocking patents reaches 68% of total patents. Whereas the share of used patents is lowest in chemicals and pharmaceuticals compared to the other technologies, the share of blocking patents is the highest among all technologies. The share of used patents is largest in process engineering (66%) and consumption and construction (72%). Besides chemicals and pharmaceuticals, blocking patents are most common in consumption and construction (68% each), as well. In technological fields like semiconductors, biotechnology and software, strong interdependencies among innovations and the increasing use of patents have favored a great dispersion of rights among patent holders (Heller and Eisenberg, 1998; Shapiro, 2000). As mentioned before, excessive intellectual property right (IPR) fragmentation or 'over-fencing' raise transaction costs in the market for technology and explains the large number of unused patents.

Small and medium-sized firms are more active in commercial use and licensing compared to large firms. Patent sale and new firm formation spawned by patents are also more frequently observed for small and medium-sized firms then for large firms. The large share of spinoffs spawned by or through small firms (17%) is probably due to more formal and rigorous project evaluation methods (Cassiman and Ueda, 2005) or greater organizational inertia and less job satisfaction in large bureaucratic firms (Cassiman and Ueda, 2005; Elfenbein et al., 2010).

Finally, large firms have larger shares of unused and blocking patents in their portfolio. Larger firms are characterized by a higher patent propensity than small or medium-sized firms. This patenting behavior, in turn, increases the share of unused patents. In addition, due to their financial strength, larger firms can play the 'strategic patenting game' relatively more easily than smaller firms. Hence, patents are heavily used for blocking competitors (von Graevenitz et al., 2007).

These differences (based on a test comparing the means of the variables) are again statistically significant at the 1% level, with the exception of blocking as a motive for filing a patent, which does not show statistically significant differences across countries and cross-licensing as a use of patents, which does not show significant differences across firm sizes.

3.2. Variables and method

Dependent variables

Our investigation focuses on four combinations of reasons for filing a patent and patent use. Based on the information obtained from the survey, we define two dichotomous variables. The first one is *Blocking* that takes value 1 if blocking competitors (avoid others patent similar inventions, either complements or substitutes) was an important reason for patenting the invention - scores 4 (important) or 5 (very important) on a five-point Likert scale. The second variable is *Used*. It is equal to 1 when the patent has been used either *internally* (the PatVal2 survey asked whether the patent was used commercially in a product, service or a manufacturing process) or *externally* (whether the patent was licensed or sold to another party, or used to found a new company). Table 3 described above reports the shares of blocking and used patents.

The combinations of *Used* and *Blocking* lead to the following categories (see also Table 1 above): *Strategic Use*, when *Used* = 1 and *Blocking* = 1; *Commercial Use*, if *Used* = 1 and *Blocking* = 0; *Strategic Non-use* if *Used* = 0 and *Blocking* = 1; and *Sleeping* patents, when both *Used* = 0 and *Blocking* = 0. Table 4 describes the distribution of these four types of uses in our sample.

Table 4 about here

Most of the patents (39%) are filed for strategic use. These patents – in the literature also referred to as 'block to play' patents – are patents filed to prevent others from patenting similar inventions and are used in licensing/cross-licensing deals (Cohen et al. 2002). However, strategic use also include blocking patents used commercially in new products, services or processes. As mentioned before, licensing and cross-licensing account for a small share of patents in our sample. 20% of the patents are filed for commercial use (internally or externally) without the intention of blocking others. This share is almost only half as large as that of patents filed to block competitors. The share of unused patents taken to prevent others from inventing similar inventions (strategic non-use), referred to as 'block to fence' patents in Cohen et al. (2002), amounts to 27%.[8] Finally, 14% of the patents in our sample are 'sleeping' patents as they are neither filed to be used, nor to block competitors.

A few differences regarding the combinations of reasons for patenting and the type of use also emerge across technologies. The largest share of patents filed for strategic use is observed in construction and consumption (50%) followed by process engineering (43%). In the remaining technologies, strategic use concern a bit more than one third of the patents. Commercial use is less frequent in chemicals and pharmaceuticals (16% compared to the about 20% in the other fields). In chemicals and pharmaceuticals, however, the share of strategically non-used patents is the largest: 33% vs. 28% in electrical and mechanical engineering, 27% in instruments and lower in the remaining technologies. Sleeping patents, instead, are least frequent in construction and consumption (10%) and process engineering (12%) compared to 15-16% in the other technologies.

As expected, large firms have fewer patents that are used strategically (large firms: 37% vs. medium-sized firms: 47% and small firms: 44%). However, large firms exhibit the largest share of strategically non-used patents (31% of patent are filed to block competitors without the intention to use the patent, twice the share of small and medium-sized firms) and sleeping patents (large firms: 16% vs. 11% and 9% for small and medium-sized firms).

These differences (based on a test comparing the means of the variables) are statistically significant at the 1% level.

Key regressors

Our first covariate of interest is technological complexity. We built two alternative measures of technological complexity. As a first measure, we use 30 OST-INPI technology area of the patent, which capture complexity and other technology-specific characteristics. Following von Graevenitz et al. (2013, Table VIII), we classify the 30 OST technology areas in complex and discrete technology areas (see Table 5). Complex technology areas include technologies used in new

---

[8] Our measures of 'block to play' and 'block to fence' patents differ from Cohen et al (2003) on two grounds. First, our measures combine reasons for patenting and actual patent use whereas their measures build on reasons for patenting. Second, among the reasons for patenting Cohen et al (2002) do not explicitly account for commercial use while in our survey the set of (actual) uses include commercial use in new products, services or processes.

products "comprised of numerous separately patentable elements" (Cohen et al. 2002: 1356) such as electrical machinery, electrical energy, information technology and semiconductors. Instead, discrete technological areas include technologies used in new products "comprised of a relatively discrete number of patentable elements" (ibid.) such as organic chemistry and pharmaceuticals.

Pharmaceuticals and cosmetics are used as reference category in the regressions. The largest shares of patents are assigned to the areas analysis, measurement and control technology (8%) and transportation (7%). The smallest shares are assigned to nuclear engineering (0.4%) and space technology and weapons (0.5%).

The second measure of technological complexity draws on mutually critical (X or Y) references[9] between firms' patent portfolios. For each OST technology area von Graevenitz et al. (2013) counted the frequency with which three firms hold EP patents reported in the other two firms' patents as X or Y references in the period 1988-2002. Our variable (TRIPLES) is equal to the average number of triples (cross X or Y references among three firms) over the period 1988-2002 and varies across the 30 OST technology areas. A larger average number of triples signals more complexity and transaction costs in the market for technology. Triples on average amount to 20.8 and vary between 0 and 118.

We further adopt different competition measures. The first and most straightforward indicator is the number of applicants in the same 4-digit IPC technology field of the patent by 1998 (IPC4_NFIRMS). The measure on average amounts to 7,181 firms and varies between 127 and 30,748 firms. We obtained the IPC technology fields from the PATSTAT dataset. We also used other concentration indices like the concentration ratio the Herfindahl index with various levels of technological aggregation.

We also rely on information gathered through the PatVal2 survey to measure the extent of competition that the firm experienced during the research process leading to the patent. PatVal2 asked whether during the invention process there were one (ONE COMPETITOR) or more other parties (SEVERAL COMPETITORS) competing with the applicant for the patent. 7% of the respondents reported one competitor during the time of the invention and 26% answered that they had several competitors.

[9] References are patent or non-patent documents identified by the patent examiners as state of the art. The latter may impede patentability of the invention in case – given the state of the art – the invention under consideration no longer meets the requirements for patentability, i.e. novelty or inventive step. At the EPO, examiners classify patent references according to their meaning and significance. Whereas, e.g. A-type references only describe related state of the art, X and Y-type citations are of highest relevance, since they either taken alone (X-type references) or in combination with other references (Y-type references) impede novelty and inventive step of at least part of the claimed scope of protection (see http://www.epo.org/law-practice/legal-texts/guidelines.html, accessed on December 16, 2014).

As far as patent value is concerned, we employ the size of the INPADOC[10] patent family (FAMSIZE), which measures the number of equivalents or patent applications directly or indirectly linked through a priority date, and the number of claims reported in the patent document (N_CLAIMS). The number of claims defines the scope of patent protection; a wider scope provides a potentially greater economic value compared with a narrow scope. Family size on average amounts to 29 applications (min = 1; max = 5,051). The number of claims on average amounts to 16 (min = 0; max = 187). [11]

In addition, we account for the generality of the focal patent (GENERALITY). Following Hall et al. (2001), generality is computed as $1-\sum_{j=1}^{n_i} s_{ij}^2$ where s_{ij} is the percentage of citations received by patent i that belong to patent class j (4-digit), out of n_i 4-digit patent classes. The larger the generality index the wider the set of different technologies that cite the focal patent and thus the larger the impact of the technology in terms of potential applications. Generality on average amounts to 0.08 (min = 0; max = 0.86).

Legal validity is measured by the number of overlapping claims with earlier patents, i.e. X or Y references assigned by patent examiners (XY_PATENT_REF). The presence of X or Y references may signal weakness of the patent in terms of novelty and/or inventive step, and it may affect the probability of legal disputes. The number of X and Y references amounts to 2.79 on average and varies between 0 and 32. In addition, after grant, EP patents can be opposed by third parties at the EPO. Whether oppositions are a measure of uncertain validity or patent value is part of a debate (Hall et al 2009). We use a dummy variable that takes value 1 if the patent has received an opposition at the EPO (OPPOSITION). 4.6% of the patent in our sample were opposed after grant. Finally, TOT_ECLA refers to the number of ECLA (European Classification System) technology classes the patents were assigned to. The variables amounts to 2.7 on average, varying between 1 and 48.

Table 5 provides the descriptive statistics of all variables employed in the multiple correlation analysis. Pairwise correlations of the variables described above are not reported for reasons for space.

Table 5 about here
----

[10] INPADOC (International Patent Documentation Center) is a database maintained by the EPO containing information about patent families and the legal status of patent applications (see http://www.epo.org/searching/essentials/ patent-families /inpadoc_de.html, accessed on December 16, 2014).

[11] The number of claims refers to the count at the time of extracting the data from the database, i.e. not to the number of claims at the time of the application of the patent. Zero claims may occur if during the examination process the examiner limits the scope of protection until no claims are left. This typically leads to a withdrawal or a refusal of the patent application.

Controls

We include firm level control variables in our estimates. Moreover, we control for the legal status of the application as of April 2011 – PENDING, GRANTED, WITHDRAWN and REFUSED. N_INVENTORS controls for the number of inventors listed on the patent document. On average, patents list 3 inventors, varying between 1 and 50 inventors. Firm Size is measured by the number of employees. As mentioned before, the PatVal2 survey asked to classify the employer's organization in one of the following size categories: "1-9 employees", "10-19 employees", "20-49 employees", '50-99 employees, "100-249 employees", "250-499 employees", "500-999 employees", "5000 and more employees". More than 50% of the firms in our sample are large firms (>500 employees). 17% of the firms have less than 100 employees.

The size of the firms' patent stock in portfolio is measured at the corporate level and is calculated with a declining balance formula with a 15% depreciation rate (PATENT_STOCK). This variable controls for the fact that firms with large patent portfolios have strong bargaining power that they can leverage in licensing and cross-licensing deals. In addition, however, the owners of large patent portfolios face a lower risk of litigation and therefore have smaller incentive to resort to cross-licensing (Galasso, 2012). Finally, firms with large patent portfolios may be unable to recognize and fully exploit the economic value of all their patents (Rivette and Kline, 2000). The patent stock amounts to 1,001 patents on average and varies between 0.08 and 13,017 patents.

Finally, we control for patents' priority years (2003, 2004 and 2005) the geographical area of residence of the inventors: Europe (20 countries), Israel, Japan and the U.S.

4. Results

This section illustrates the results obtained from bivariate probit estimations of *Blocking* and *Used*. The marginal effects of the probabilities of *Blocking* and, respectively, *Used* in the full sample of 10,684 observations are not shown for reasons of space. Table 6 reports the marginal effects of the regressors on the predicted probabilities of the four combinations of *Blocking* and *Used*, i.e., *Strategic Use*, *Commercial Use*, *Strategic Non-use* and *Sleeping patents*.

Table 6 about here

Results are in line with our expectations. We start by examining the association between complexity and blocking and patent use. We analyze complexity via the 30 OST technology area dummies, with 'pharmaceutical and cosmetics' as the reference group. As expected, the marginal effects of complex technological fields like electrical devices, engineering and energy, audio-visual technologies, information technology, semiconductors and optics on the predicted probabilities of *Strategic Use* and *Commercial Use* are positive and significant. By contrast, the marginal effects of these technological classes on *Strategic Non-use* are negative and significant. These, and other technological classes are also negatively related to *Sleeping patents*, although the size of these marginal effects is smaller compared with those on *Strategic Non-use*, suggesting that blocking to fence in pharmaceutical and cosmetics is much more relevant than non-use due to nonstrategic reasons (sleeping).

To explore the association between complexity and patent use further, we use the average number of triples computed by von Graevenitz et al. (2013). The marginal effects on the four bivariate probabilities are never significant.

The marginal effects of competition are more clear-cut compared with those of technological complexity. The presence of one competitor for the patent is positively associated with *Strategic Use* of patents and negatively associated with *Sleeping patents*. This suggests that patent holders facing competition are more likely to rely on blocking patents - either to protect their product or process innovation or to ensure freedom to operate through licensing and cross-licensing agreements (block to play). However, the negative marginal effect of several competitors on *Commercial Use* and the positive marginal effect on *Strategic Non-use* suggest that a large number of competitors (intense technological competition) also spur investments in patent fences.

We also use an additional measure of competition, which is the number of patentees in the same 4-digit IPC technological class of the patent (IPC4_NFIRMS). We find that *Strategic Use* is less likely when the number of patent applicants in the same technological class is large, while *Sleeping patents* are more likely to occur. This result seems at odds with the effects of the presence of several competitors for the patent. However, it also confirms that these variables measure two different dimensions of the technological competitive environment. Precisely, the variable SEVERAL_COMPETITORS measures competition for a specific patent and thus it may signal the importance of the patent as a strategic weapon (strategic use and non-use). Instead, a large number of patent holders (IPC4_NFIRMS) proxy for a broader dimension of the technological environment, that is the dispersion of patent rights. As such, a large number of patent holders generates a high risk of holdup and transaction costs, which hamper strategic and nonstrategic use of patents.

We used numerous measures of patent value or importance. FAMILY_SIZE and OPPOSITION are positively associated with *Strategic Use* and negatively to *Sleeping patents* while they are not correlated with S*trategic Non-use*. This suggests that more valuable patents are likely to be used to block competitors and possibly to play, but not to fence. At the same time, more valuable patents are less likely to remain *Sleeping*, which suggests that a large family size and oppositions received indicate the importance of the patent for rivals.

TOT_ECLA, CLAIMS and GENERALITY are negatively related with *Strategic Use* and positively related to *Sleeping patents*. These results suggests that patents with a broad technological scope and protection scope may be difficult to exploit both in the market for products and in the market for patents (licensing, cross-licensing and sale).

The marginal effects of XY_PATENT_REF, our proxy for legal validity, are generally insignificant.

Table 6 shows that larger firms have a higher propensity to have unused blocking patents (*Strategic Non-use*) and a lower propensity to *Commercial Use*. We also find that the marginal effect of very large firms (more than 5000 employees) compared to SMEs (1 to 250 employees) is positive and significant on sleeping patents and negative and significant on *Strategic Use*, while companies in other size classes display similar effects as SMEs. The marginal effects of PATENT_STOCK are in line with those of firm size.

Finally, in order to check for the robustness of our results and to investigate more deeply blocking and used patents, we run separate probit regressions of blocking patents used for licensing (*strategic external use*) and blocking patents used internally (*strategic internal use*). Most results are coherent with the results presented in this Section. We also find that *strategic external use* (corresponding to blocking to play) is mainly present in complex technological fields like electrical devices, engineering and energy, audiovisual technologies and information technology.

5. Conclusions

Our multivariate analysis shows that patent use varies significantly between complex technologies and discrete technologies. Patents in complex technologies are more likely to be used (both strategically and commercially) and less likely to remain unused. The difference between complex and discrete technologies is particularly significant with respect to strategic non-use, which is more likely to occur in pharmaceuticals and cosmetics compared to, e.g., electrical machinery, telecommunications and information technology. As Cohen et al. (2002) have noted, firms in complex product industries are more likely to accumulate patents to gain freedom to operate and increase bargaining power in litigation and cross-licensing ('block to play').

Second, we find that the presence of more competitors increases the likelihood of strategic patenting (strategic use and strategic non-use). Besides competition for the patent, we used various measures of concentration of patent rights, including the number of patent holders in the same four-digit technology class of the patent, which is positively associated with sleeping patents and negatively associated with strategic use. This result suggests that the dispersion of patent rights increases transaction costs and reduces the possibility of bargaining to gain freedom to operate (Heller and Eisenberg, 1998). However, in unreported probit regressions we found that the number of patent holders in the same technology area is positively associated with the probability of external strategic use ('block to play' patents), which is at odds with a transaction costs explanation. Moreover, probit regressions of external strategic use show that the marginal effect of complex technologies is positive and significant. These findings suggest that both competition for the patent and the fragmentation of patent rights spur external strategic use. Such behavior is probably driven by the need to access complementary knowledge owned by other patent holders.

We also find that the number of patent holders is negatively associated with internal strategic use. This suggests that a large number of patent holders increase the risk of infringement and hold-up. Firms that use patents in new products or processes are particularly concerned about the hold-up risk because of the sunk costs required by the production and commercialization of innovations. In these conditions licensing or selling is less risky than 'making'.

As expected, patents with relatively many X and Y references (a proxy for uncertain validity) are less likely to be used, although the marginal effects are not significant.

Finally, the likelihood of patent use decreases as firm size and the size of patent portfolio grow, while the likelihood of nonuse (both strategic nonuse and sleeping patents) increases. This confirms that the owners of large patent portfolios often use patents to block competition or to reduce the risk of holdup.

Future research

Our analysis explores an important phenomenon not sufficiently investigated in previous studies. We contribute to the literature on innovation by showing various correlates of patent use (and non-use) and numerous factors that can help understand better the characteristics of patenting strategy. While our results are mainly descriptive, we think that they can provide an important foundation for future theoretical and empirical studies.

Future research could explore in more depth the conditions favoring or hampering the commercial exploitation of patents in new products and services or the transfer of patent rights in the market for technology. We need to understand better the mechanisms through which patent protection and exploitation strategies work. This calls for closer scrutiny of firms' IP management strategies, the changing set of technological opportunities and the strategic interactions among firms in different competitive environments.

Policy implications

Our analysis bears several policy implications, primarily related to the large share of unused patents and the potential barriers to a more efficient use of patented technology. Our analysis shows that several patents remain unused for strategic reasons and, hence, produce private benefit to the patent holder. However, they may conceivably be associated with anticompetitive behavior or depict a waste of resources from a societal point of view.

Even if technological markets (sale and licensing) were more efficient, the owners of large patent portfolios in industries like semiconductors and biotechnology would probably continue to hoard blocking patents as they are threatened by the risk of hold-up and blocking patents of other players. The arsenal of own (unused) patents may be used as a bargaining chip in infringement suits or cross-licensing. Patent policies that limit the scope and enforceability of patents may reduce IP fragmentation and blocking patents. However, these policies would also impact upon other patents, including unused patents that are not necessarily filed for strategic, anticompetitive reasons.

To stimulate more intense exploitation of sleeping patents there exist alternatives to compulsory licensing such as the license of right provisions, which grants a reduction on the renewal fees in the patentee voluntarily allows any third party to use the patent in return for a reasonable compensation (Rudyk 2012).

Some patents are probably not used because the owner has already decided not to exercise the option to use or has not managed to use them for instance for the difficulty to find a licensee or an acquirer. Policies oriented to improve the efficiency of the technology market, for instance policies that favor the take-off of online marketplaces, should support a more intense use of unused patents by lowering some barriers to trade. There exist public initiatives in some countries targeted at the valorization of patents through actions directed, for example, to patent exchange platforms (e.g., IP Marketplace in Denmark and the Innovation Market in Germany) and patent aggregators like patent funds (e.g., France Brevets). The distinction between strategic non-use and sleeping patents is important from this perspective, since their roles in firm strategy as well as their treatment in public policy are likely to be very different. Strategic non-use is 'valuable' to patent owners to the extent that it prevents others from patenting similar inventions and competing in the same market. This can be considered a kind of endogenous choice of patent scope. It is difficult for public policies to foster a more intensive use of these patents. Instead, although several sleeping patents have probably limited value, public policy could reduce the rate of sleeping patents more succinctly by reducing transaction costs in the market for technology.

References (incomplete)

Arora, A., Fosfuri, A., Gambardella, A. (2001). Markets for technology: The economics of innovation and corporate strategy. MIT press.

Arora A., and Merges, R. (2004). Specialized supply firms, property rights and firm boundaries. *Industrial and Corporate Change*, 13(3): 451.

Bessen, J. (2008). The value of US patents by owner and patent characteristics. Research Policy, 37(5): 932-945.

Cohen W.M., Nelson R.R. and Walsh, J.P. (2000). Protecting their intellectual assets: appropriability conditions and why U.S. manufacturing firms patent (or not). NBER Working Paper no. 7522.

Cohen,W.M., Goto, A. Nagata, A. Nelson, R.R. and Walsh, J.P. (2002) R&D spillovers, patents and the incentives to innovate in Japan and the United States, Research Policy, 3: 1349–1367.

De Rassenfosse, G., Dernis, H., Guellec, D., Picci, L., Van Pottelsberghe de la Potterie, B. (2013). The

Galasso, A. (2012). Broad Cross-License Negotiations. *Journal of Economics and Management Strategy*, 21, pp. 873–911.

Gambardella A., Giuri P., Luzzi A. (2007). The market for patents in Europe. Research Policy 36: 1163–1183.

Gambardella, A., Harhoff, D., Verspagen, B. (2008). The value of European patents. European Management Review, 5(2): 69-84.

Giuri P., Mariani M. et al. (2007). Inventors and Invention Processes. Results from the PatVal-EU Survey, Research Policy, 36(8): 1107-1127.

Giuri, P., Torrisi, S. (2010). Cross-licensing, cumulative inventions, and strategic patenting. European Policy on Intellectual Property (EPIP) Conference 2010, Maastricht, Sept. 20-21: 2010.

Hall, B. H., and R. H. Ziedonis (2001). The determinants of patenting in the U. S. semiconductor industry, 1980-1994. Rand Journal of Economics 32: 101-128.

Hall B. H., A. Jaffe, and M. Trajtenberg (2005), "Market Value and Patent Citations," Rand Journal of Economics 36: 16-38.

Hall, B.H., Thoma, G. and Torrisi, S. (2009). Financial Patenting in Europe. European Management Review 6: 45-63.

Harhoff, D., Scherer, F. M., Vopel, K. (2003). Citations, family size, opposition and the value of patent rights. Research Policy, 32(8): 1343-1363.

Harhoff, D., Hoisl, K. (2007). Institutionalized incentives for ingenuity—patent value and the German Employees' Inventions Act. *Research Policy*, *36*(8), 1143-1162.

Heller, M., Eisenberg, R. (1998). Can Patents Deter Innovation? The Anticommons in Biomedical Research, Science, 280 May: 698-701.

Jung, T. and Walsh, J.P 2014. Technology Trajectories and Firm Patenting Strategy: Evidence from a US Inventor Survey. Discussion Paper.

Nagaoka, S, Walsh, J. (2009b). Commercialization and other uses of patents in Japan and the US: Major findings from the RIETI-Georgia Tech inventor survey",RIETI Discussion Paper Series 09-E-011

Noel, M. and Schankerman, M. (2013), Strategic Patenting and Software Innovation. The Journal of Industrial Economics, 61: 481–520

Rivette, K.G., Kline, D. (2000). Discovering new value in intellectual property. Harvard Business Review 78: 54-66.

Rudyk, I. (2012). The License of Right, Compulsory Licensing and the Value of Exclusivity. GESY, University of Munich, Discussion Paper No. 415.

Scherer, F.M. and Harhoff, D. (2000). Technology policy for a world of skew-distributed outcomes, *Research Policy*, Vol. 29, pp. 559-566.

Scotchmer, S., (1991), Standing on the shoulders of giants: cumulative research and the patent law, Journal of Economic Perspectives, 5: 29-41.

Thornhill, S., R. Amit. (2001). A Dynamic Perspective of Internal Fit in Corporate Venturing. Journal of Business Venturing 16(1), 25-50.

von Graevenitz, G., Wagner, S., Hoisl, K., Hall, B.H., Harhoff, D., Giuri, P., Gambardella, A. (2007). The strategic use of patents and its implications for enterprise and competition policies. Report for the European Commission. Brussels, European Commission.

Table 1. Used and unused patents

		Patent use	
		Used	**Not used**
Motives for patenting	**Blocking**	Strategic use - e.g., block to play	Strategic nonuse -e.g., block to fence
	No blocking	Commercial use -internal (e.g., in a new product or service) or external (e.g., licensing)	Sleeping patents

Table 2. Importance of reasons for patenting (median values. Scale: 1–5).

	Commercial exploitation	**Licensing**	**Cross licensing**	**Prevention of Imitation**	**Blocking patents**	**Reputation**	**Prevention of infringement suits**	**Pure defense**	**Technical standards**
Total	5	3	3	5	4	3	3	4	1
EU + Israel	5	3	2	5	4	3	3	3	1
U.S.	5	3	2	5	4	3	3	3	1
Japan	5	3	3	5	5	2	4	4	1
multivariate test on means	***	***	***	**	***	***	***	***	n.s.
Electrical engineering	5	3	3	4	4	3	3	4	1
Instruments	5	3	3	5	4	3	3	4	1
Chemicals and Pharmaceuticals	5	3	2	5	4	3	3	3	1
Process engineering	5	3	2	5	4	3	3	4	1
Mechanical engineering	5	3	2	5	4	3	3	4	1
Consumption and Construction	5	3	2	5	5	3	3	4	1
multivariate test on means	***	***	***	***	***	***	***	**	n.s.
Small firms [<100 empl.]	5	4	2	5	4	3	3	3	1
Medium sized firm [100-249 empl.]	5	2	2	5	4	3	3	4	1
Large firm [>=250 empl.]	5	3	3	5	4	3	3	4	1
multivariate test on means	***	***	***	***	***	***	***	***	**

Notes: *** p<0.01, ** p<0.05, * p<0.1, n.s.: not significant.

Authors' computations based on PatVal2 survey data. Number of observations varies between 40 and 10684 depending on the subsample.

Table 3. Uses of patents: Share of total patents.

	Commercial Use of the patent	Patent sale	Patent licensing	Cross licensing	Start-up	Used patent	Blocking patent
Total	0.55	0.04	0.07	0.01	0.04	0.58	0.66
EU + Israel	0.56	0.04	0.07	0.01	0.04	0.60	0.62
U.S.	0.56	0.08	0.11	0.02	0.06	0.61	0.64
Japan	0.50	0.02	0.04	0.004	0.01	0.52	0.77
multivariate test on means	***	***	***	***	***	***	***
Electrical engineering	0.54	0.04	0.07	0.02	0.03	0.57	0.64
Instruments	0.54	0.06	0.06	0.01	0.05	0.57	0.65
Chemicals and Pharmaceuticals	0.46	0.05	0.07	0.01	0.03	0.51	0.68
Process engineering	0.62	0.05	0.08	0.01	0.04	0.66	0.66
Mechanical engineering	0.55	0.03	0.04	0.004	0.03	0.57	0.66
Consumption and Construction	0.68	0.05	0.09	0.01	0.08	0.72	0.68
multivariate test on means	***	***	***	***	***	***	n.s.
Small firms [<100 empl.]	0.63	0.12	0.16	0.01	0.17	0.74	0.59
Medium sized firm [100-249 empl.]	0.70	0.06	0.09	0.01	0.05	0.74	0.64
Large firm [>=250 empl.]	0.52	0.03	0.04	0.01	0.01	0.54	0.67
multivariate test on means	***	***	***	n.s.	***	***	***

Notes: *** p<0.01, ** p<0.05, * p<0.1, n.s.: not significant.

Authors' computations based on PatVal2 survey data. Number of observations varies between 590 and 10684 depending on the subsample.

Multiple uses of the patent (e.g. commercial use and licensing, licensing and new firm, etc.) are possible. Hence, the different types of use (columns 1 to 5) do not add up to the total share of used patents reported in column 6.

Table 4. Used and unused patents: Share of total patents.

	Strategic use [Used=1&Blocking=1]	**Commercial use** [Used=1&Blocking=0]	**Strategic non-use** [Used=0&Blocking=1]	**Sleeping patents** [Used=0&Blocking=0]
Total	0.39	0.20	0.27	0.14
EU + Israel	0.37	0.22	0.25	0.15
U.S.	0.40	0.22	0.24	0.14
Japan	0.41	0.11	0.36	0.12
multivariate test on means	**	***	***	***
Electrical engineering	0.36	0.21	0.28	0.15
Instruments	0.38	0.20	0.27	0.16
Chemicals and Pharmaceuticals	0.34	0.16	0.33	0.16
Process engineering	0.43	0.22	0.22	0.12
Mechanical engineering	0.38	0.19	0.28	0.15
Consumption and Construction	0.50	0.22	0.18	0.10
multivariate test on means	***	***	***	***
Small firms [<100 empl.]	0.44	0.29	0.15	0.11
Medium sized firm [100-249 empl.]	0.47	0.27	0.17	0.09
Large firm [>=250 empl.]	0.37	0.17	0.31	0.16
multivariate test on means	***	***	***	***

Notes: *** p<0.01, ** p<0.05, * p<0.1, n.s.: not significant.

Authors' computations based on PatVal2 survey data. Number of observations varies between 599 and 10684 depending on the subsample.

Table 5. Descriptive statistics (N. 10,684)

Variable	Mean	S.D.	Median	Min	Max
BLOCKING	0.66		1	0	1
USED	0.58		1	0	1
TRIPLES	20.77	29.79	6.71	0	117.70
IPC4_NFIRMS	7181	7123	4558	127	30748
ONE_COMPETITOR	0.07		0	0	1
SEVERAL_COMPETITORS	0.26		0	0	1
DUMMY_MISSING_COMPETITOR	0.12		0	0	1
OPPOSITION	0.02		0	0	1
XY_PATENT_REF	2.79	2.79	2	0	32
TOT_ECLA	2.73	2.15	2	1	48
CLAIMS	16.25	11.75	13	0	187
FAMSIZE	29.01	54.71	33	1	5051
NR_INVENTORS	2.55	1.85	2	1	50
GENERALITY	0.08	0.18	0	0	0.86
DUMMY_MISSING_GENERALITY	0.42		0	0	1
<100 EMPLOYEES	0.17			0	1
100-249 EMPLOYEES	0.06		0	0	1
250-499 EMPLOYEES	0.05		0	0	1
500-999 EMPLOYEES	0.05		0	0	1
1000-4999 EMPLOYEES	0.13		0	0	1
>5000 EMPLOYEES	0.54		1	0	1
PATENT_STOCK	1001.18	2218.07	151.93	0.08	13016.99
PRIORITY_YEAR 2003	0.33		0	0	1
PRIORITY_YEAR 2004	0.37		0	0	1
PRIORITY_YEAR 2005	0.30		0	0	1
PENDING	0.38		0	0	1
GRANTED	0.38		0	0	1
WITHDRAWN	0.22		0	0	1
REFUSED	0.01		0	0	1
COUNTRIES EU	0.60		1	0	1
COUNTRY JP	0.22		0	0	1
COUNTRY IL	0.00		0	0	1
COUNTRY US	0.17		0	0	1
ELECTRICAL ENGINEERING	0.21		0	0	1
GENERAL INSTRUMENTS	0.16		0	0	1
CHEMISTRY	0.19		0	0	1
PROCESS ENGINEERING	0.15		0	0	1
MECHANICAL ENGINEERING	0.21		0	0	1
CONSTRUCTION AND CONSUMER GOODS	0.08		0	0	1

Table 6. Bivariate probit estimation
Marginal effects on the bivariate probabilities of *Blocking* and *Used*.

VARIABLES	**Strategic use** [Used=1&Blocking=1]	**Commercial use** [Used=1&Blocking=0]	**Strategic non-use** [Used=0&Blocking=1]	**Sleeping patents** [Used=0&Blocking=0]
ONE_COMPETITOR	0.076***	-0.012	-0.017	-0.047***
	(0.016)	(0.013)	(0.015)	(0.010)
SEVERAL COMPETITORS	0.057***	-0.039***	0.020*	-0.039***
	(0.012)	(0.009)	(0.011)	(0.008)
lIPC4_NFIRMS	-0.012**	0.002	0.002	0.007**
	(0.006)	(0.004)	(0.005)	(0.004)
lTOT_ECLA	-0.015**	-0.000	0.006	0.009**
	(0.007)	(0.006)	(0.007)	(0.004)
lCLAIMS	-0.028***	0.000	0.011	0.017***
	(0.008)	(0.006)	(0.007)	(0.005)
GENERALITY	-0.069***	-0.019	0.050**	0.039**
	(0.025)	(0.021)	(0.024)	(0.015)
OPPOSITION	0.064*	0.004	-0.030	-0.037*
	(0.033)	(0.027)	(0.031)	(0.020)
lFAMILY_SIZE	0.022***	-0.008	-0.000	-0.014***
	(0.006)	(0.007)	(0.009)	(0.003)
XY_PATENT_REF	-0.000	-0.004	0.005	-0.000
	(0.002)	(0.003)	(0.003)	(0.001)
100-249 EMPL	0.023	-0.006	-0.002	-0.015
	(0.021)	(0.016)	(0.019)	(0.013)
250-499 EMPL	-0.022	-0.044**	0.058***	0.008
	(0.023)	(0.017)	(0.020)	(0.014)
500-999 EMPL	-0.023	-0.059***	0.075***	0.006
	(0.022)	(0.018)	(0.021)	(0.013)
100-4999 EMPL	-0.033*	-0.051***	0.070***	0.014
	(0.018)	(0.014)	(0.016)	(0.011)
5000+ EMPL	-0.055***	-0.056***	0.086***	0.026**
	(0.018)	(0.015)	(0.017)	(0.011)
lPATENT_STOCK	-0.014***	-0.011***	0.018***	0.007***
	(0.003)	(0.003)	(0.003)	(0.002)
N_INVENTORS	0.009***	-0.000	-0.004*	-0.006***
	(0.003)	(0.002)	(0.002)	(0.002)
GRANTED	-0.000	0.011	-0.013	0.002
	(0.011)	(0.008)	(0.009)	(0.007)
WITHDRAWN	-0.085***	-0.015	0.052***	0.049***
	(0.012)	(0.010)	(0.011)	(0.007)
REFUSED	-0.035	0.027	-0.016	0.024
	(0.041)	(0.031)	(0.038)	(0.025)
El_dev_engin_energy	0.127***	0.062**	-0.121***	-0.068***
	(0.035)	(0.030)	(0.037)	(0.021)
Audio_visual	0.088**	0.081**	-0.127***	-0.043
	(0.043)	(0.036)	(0.043)	(0.026)
Telecom	0.047	0.119***	-0.152***	-0.014
	(0.037)	(0.028)	(0.035)	(0.022)
InformationTech	0.105***	0.119***	-0.176***	-0.048**
	(0.035)	(0.030)	(0.037)	(0.021)
Semiconductors	0.066	0.074**	-0.110***	-0.030
	(0.042)	(0.035)	(0.042)	(0.026)
Optics	0.066	0.082**	-0.118***	-0.029
	(0.042)	(0.034)	(0.040)	(0.025)
Anal_measur_control_tech	0.059*	0.083***	-0.117***	-0.025
	(0.034)	(0.029)	(0.035)	(0.021)
Medical_tech	0.090***	0.052*	-0.095**	-0.047**
	(0.034)	(0.031)	(0.038)	(0.020)
Nuclear_eng	0.023	0.001	-0.010	-0.014
	(0.068)	(0.057)	(0.063)	(0.043)
Org_chemistry	-0.077**	0.024	0.005	0.049**
	(0.037)	(0.032)	(0.039)	(0.023)
Macromol_chemistry_polymers	0.115***	0.054	-0.107***	-0.062***
	(0.039)	(0.034)	(0.041)	(0.024)

Table 8. (continued)

Biotechnology	-0.002	0.076**	-0.085*	0.010
	(0.044)	(0.038)	(0.047)	(0.026)
Agriculture_food_chem	0.085	0.151***	-0.204***	-0.033
	(0.052)	(0.042)	(0.049)	(0.032)
Chem_petrol_basic_mat_chemistry	0.070*	0.031	-0.063	-0.038
	(0.041)	(0.038)	(0.045)	(0.025)
Surface_tech_coating	0.134***	0.124***	-0.194***	-0.065**
	(0.044)	(0.036)	(0.044)	(0.027)
Materials_metallurgy	0.106***	0.062*	-0.113***	-0.055**
	(0.041)	(0.035)	(0.041)	(0.025)
Chemical_eng	0.101***	0.123***	-0.179***	-0.045*
	(0.038)	(0.032)	(0.039)	(0.023)
Mat_processing_textiles_paper	0.075**	0.083***	-0.124***	-0.034
	(0.037)	(0.032)	(0.038)	(0.023)
Handling_printing	0.175***	0.074**	-0.154***	-0.095***
	(0.035)	(0.031)	(0.037)	(0.022)
Agric_food_proc_mach	0.122**	0.052	-0.107*	-0.066**
	(0.053)	(0.049)	(0.057)	(0.033)
Environm_tech	0.098**	0.132***	-0.187***	-0.042
	(0.049)	(0.046)	(0.055)	(0.029)
Machine_tools	0.180***	0.078**	-0.161***	-0.098***
	(0.042)	(0.032)	(0.039)	(0.026)
Engines_pumps_turbines	0.052	0.042	-0.068*	-0.026
	(0.040)	(0.033)	(0.039)	(0.024)
Thermal_proc_appar	0.087**	0.077**	-0.122***	-0.043*
	(0.042)	(0.036)	(0.042)	(0.026)
Mechanical_Elements	0.059	0.096***	-0.131***	-0.023
	(0.037)	(0.031)	(0.037)	(0.023)
Transport	0.043	0.059*	-0.083**	-0.018
	(0.036)	(0.031)	(0.037)	(0.022)
Space_technology_weapons	0.096	0.075	-0.123**	-0.048
	(0.064)	(0.051)	(0.061)	(0.039)
Consumer_goods_equip	0.140***	0.080**	-0.147***	-0.074***
	(0.039)	(0.032)	(0.039)	(0.024)
Civil_eng_build_mining	0.174***	0.075**	-0.155***	-0.094***
	(0.039)	(0.032)	(0.039)	(0.024)
EU	-0.045***	0.008	0.009	0.028***
	(0.012)	(0.010)	(0.011)	(0.007)
JP	0.001	-0.071***	0.079***	-0.009
	(0.017)	(0.012)	(0.014)	(0.010)
IL	-0.007	-0.094*	0.109	-0.007
	(0.075)	(0.054)	(0.066)	(0.045)
Observations	10,684	10,684	10,684	10,684

Notes: Robust standard errors are in parentheses, adjusted for clusters by firms' identifier. All models include dummies for missing values for generality, missing values for competition, and priority year of the patent. The baseline category for technological class dummies is Pharmaceutical and Cosmetics.
* $p < 0.10$. **$p < 0.05$. ***$p < 0.01$