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

Salvatore Torrisi (*University of Bologna and CRIOS-Bocconi University*)

Alfonso Gambardella (*CRIOS - Bocconi University*)

Paola Giuri (*University of Bologna*)

Dietmar Harhoff (*Max-Planck-Institute for Innovation and Competition
and Ludwig-Maximilians-University*)

Karin Hoisl (*University of Mannheim, Copenhagen Business School
and Max-Planck-Institute for Innovation and Competition*)

Myriam Mariani (*CRIOS - Bocconi University*)

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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 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, type of applicant, and the competitive environment from where these patents originate. We discuss our results and derive an agenda for future research on innovation and patent policy.

Keywords: intellectual property, blocking patents, unused patents, hold-up, patent thickets, licensing

JEL classification: L13, L20, O34

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Corresponding author: Salvatore Torrisi (torrisi@unibo.it)

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 and patents that are not used for other (non-strategic) reasons. 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 from 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 2012¹, and USPTO applications rose from 390,733 in 2005 to 542,815 in 2012². 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 suggesting 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 for maintaining market power and reducing competition (Bessen and Meurer, 2008; Boldrin and Levine, 2013). Strategic patenting,

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.

which is particularly important in cumulative technologies like semiconductors, software, and business methods, often results in 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 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).

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 unused blocking patents, and to examine their characteristics and correlates. Because sleeping patents do not necessarily carry any strategic value, actions that try to encourage their use may be more effective as companies will not oppose their exploitation.

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 patents uses. The first type is *commercial use*, which includes patents used either internally in new products or processes or externally through licensing, sale and spinoffs. The second type is *strategic non-use* – exemplified by unused patent applications filed to create a fence to prevent others from patenting similar inventions (Cohen et al. 2002) or to give their holders freedom to operate beyond the product and technology space already occupied. Finally, the third type is *sleeping patents* - patent applications filed for reasons different from commercial use and blocking other parties. This study focuses 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 motives to patent (Blind et al., 2006 and Blind et al., 2009), 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 it separates empirically strategic patents that are not used commercially from patents that are merely sleeping, i.e., not performing any function and simply dormant by the applicants. This is one of the first papers that can draw this distinction empirically.

We use data on inventions as described in 22,567 patent applications collected through the PatVal2 survey conducted between 2009 and 2011 on EPO applications with priority dates between 2003 and 2005, and directed to inventors resident in 20 EU countries, Israel, the US and Japan. We provide new evidence about the use of patented inventions and the reasons for patenting, with data that allow for comparisons across firms of different size and patenting activity, industries, and geographical areas. Moreover, our empirical setting allows us to focus on patents rather than firms' patenting strategy in general, therefore reducing the unobserved heterogeneity problems that are typical of studies whose unit of analysis is the firm or the industry. Moreover, it allows a deep exploration of the motivations for patenting and the detailed patent and technological characteristics associated with different uses, while controlling for several patent owner characteristics.

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

As noted in the introduction, distinguishing between the characteristics of *commercial use*, *strategic non-use* and *sleeping patents* is an important novel aspect of our analysis compared to

extant literature. Besides the traditional role of patents as a mechanism that provides an exclusionary right to use inventions in the market, the literature has examined various motives for patenting like prevent litigation, reduce the risk of holdup, and block other patents.

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') (e.g., Cohen et al. 2002). However, only very few blocking patents are actually used in licensing and cross-licensing. A large number of blocking patent applications are filed to protect inventions that are either used or not used commercially. The latter, often referred to as 'blocking to fence' patents (Cohen et al. 2002), 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. Sleeping patents may also have an option value. In conditions of high economic uncertainty a firm may be induced to postpone the exploitation of a patented invention in the market until its prospective profitability is optimal (Weeds, 1999). The differences between unused patents are important to distinguish offensive, potentially anticompetitive blocking from defensive or 'innocent' behavior.

The literature regarding the economics and management of patents highlights several factors that should be associated with different types of patent uses: a) patent specific characteristics such as family size, scope, generality, overlapping claims and oppositions received; b) technology specific factors - i.e., uncertainty, distance from commercial applications, complexity and concentration; c) applicant characteristics like firm size and the size of the firm's patent portfolio; d) the competitive environment where patents originate from - i.e., presence of one or more parties competing for the same patent. We review the extant literature examining these factors before exploring empirically some of these factors and their association with patent uses, controlling for several other forces. Given the paucity of available evidence on the object of our analysis, we believe that this approach can offer useful insights into the conditions underlying the use and non-use of patents.

Complexity

The transaction-oriented view on IPR posits that intellectual property reduces transaction costs in the market for products (Arora and Merges, 2004). Moreover, a patent is 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 the use of technology: by granting a monopoly on inventions they restrict use and increase price. The patent owner may also find it difficult or not convenient to exploit the invention for lack of complementary assets, strategic reasons (e.g., to avoid the entry of competitors) and bargaining inefficiencies (e.g., 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 (Heller and Eisenberg, 1998: 699). Transaction costs resulting from the explosion of patent applications are particularly large in complex product industries like telecommunications, semiconductors and software, 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.

Overlapping patent rights imply 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. Instead, in discrete product industries (like chemicals and pharmaceuticals), a limited set of patents is required to commercialize a product. In these 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).

Previous works have also studied the impact of technological characteristics on patenting. (e.g. Hall and Ziedonis, 2001; Graevenitz et al., 2013). Less known is the relationship between technological characteristics and patent use (e.g., Cohen et al. 2002; Grindley and Teece, 1997). We address this question by asking what are the differences between complex and discrete technologies in patent use. While it is difficult to predict the differences in *commercial use* between these two technologies, we expect *strategic non-use* to be more likely for patents that protect discrete technologies like pharmaceuticals.

Technological competition

Technological competition implies that a large number of firms patent in the same technological area. It is worth noting that technological complexity and competition are two distinct dimensions of the technological environment. A large number of patents and patent holders does 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 larger³. Von Graevenitz et al. (2013), for example, find a low correlation between measures 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

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>).

has positive effects on patenting of software firms. Much less explored is the association between technological competition and patent use. We address this issue in our study.

On the one hand, a large number of competitors increases the risk of being held-up by owners of blocking patents. In addition, 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 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 (a form of *commercial use*) for two reasons. First, even if licensing allows entry of new competitors, coordination among a large number of competitors to reduce 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 difficult to predict. Moreover, technological competition should prompt a more efficient use of patents. Competition may, for example, spur firms to get patented inventions faster to the market. Hence, competition could positively correlate with *commercial use* and negatively correlate with *sleeping patents*.

Patent value

There is substantial empirical evidence that most patents do not generate 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 which do not carry out any technology audit and therefore are unable to fully exploit the economic value of all their patents (Rivette and Kline, 2000).

As mentioned earlier, 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 into patent races to acquire “freedom to operate” and to use patents as a bargaining chip in litigation or cross-licensing deals.

Our empirical analysis asks whether higher value patents are more likely to be embodied in new products, licensed or used to establish new ventures (*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.⁴ Overlapping claims measure the inventive step above a competitor’s patents and thus a large number of

⁴ 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).

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 may be, the presence of X and Y references signals 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 *commercial use*. We also ask 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.⁵ 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.⁶ 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. We decided to base our

⁵ 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.

⁶ 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.

survey on EP patent applications rather than on national patent applications to be able to compare information on demographic and procedural patent features like, e.g., citation counts or probabilities of opposition filings against patent applications. The advantage of comparability, however, comes at a possible risk of the sample being selected along specific dimensions, for example, due to the so-called “home-country effect”, such that differences between European and US or Japanese patents may be overestimated (De Rassenfosse et al. 2013). On the one hand, the larger average size of the applicants reported by U.S. and Japanese respondents compared to European and Israeli respondents are consistent with this possibility (see Table A3 in the Appendix). On the other hand, 85% of all filings (applicants from all over the world) with the EPO come via national routes, i.e. the applicants file national applications in their home countries, which are transferred to the EPO within 12 months from the priority date. This could lead to a “home country effect” for European countries, as well. Overall, it is reasonable to assume that only higher expected quality patents arrive at the EPO – irrespective of whether the applicants come from Europe, the U.S., or Japan. Additionally, the costs for getting an EP patent are the same for all applicants, whether located in Europe, in the US, or in Japan. At any rate, to avoid biases because of the “home-country effect”, we control for applicant size, project size and the country of origin of inventors in all regression analyses.⁷

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. This choice was based on interviews with patent attorneys and firms in the course of the PatVal1 survey (Giuri et al. 2007). The interviews revealed that - in contrast to science – the order of the inventors listed on the patents is not decided according to any hierarchy or contribution to the invention. Hence, a random selection does not lead to any biases. The sampling procedure resulted

⁷ The country of industry of inventor is used to account for the location of the R&D unit responsible for the invention.

in 124,134 unique patent/inventor combinations (See also Appendix A1 for a more detailed description of the sampling strategy).

Based on our experiences from the PatVal1 project, we developed the survey instrument. The PatVal2 questionnaire was divided into seven sections: *Section A* covered information on the inventors' educational backgrounds; *Section B* employment and mobility; *Section C* the invention process; *Section D* inventors' motivations and rewards; *Section E* the use and value of the patent; *Section F* the European Patent System; and *Section G* personal information on the inventors.

Before sending out the questionnaire to the sampled inventors, we conducted three pre-tests. The first pre-test aimed at testing the final version of the questionnaire and the procedure to conduct the survey. The second test compared the response rates of a physical ("paper and pencil") survey with an online version of the survey⁸. Even though, particularly in Germany, the paper-based questionnaire led to considerably more responses, because of budget constraints, we had to implement an online survey for all countries. Answers to the paper-based and the online questionnaire did not vary as regards quality (number of missing observations and consistency of the responses), but we paid particular attention to responses from countries where the paper survey was likely to work better. The final pre-test asked the inventors about reasons for not responding to the survey and about their experience with the questionnaire. The reasons for not answering the questionnaire were mainly time restrictions, confidentiality issues, a general suspicion of surveys, and a lack of information about the overall project. However, in general, the inventors described the questionnaire as clear and easy to handle.

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 contacted the inventors by mail and provided them with a cover letter asking to fill out an online questionnaire on a website that they could access through a personal ID and a password.

⁸ In this pretest, 50% of the inventors received a paper questionnaire together with a prepaid return envelope, the remaining 50% was provided with a letter containing a link leading to an online questionnaire.

Support letters from the European Commission and the EPO emphasized the importance of the project. Enclosed the inventors also received a summary page containing information about the patent the questionnaire was referring to, including the names of co-inventors, the title of the patent application, the EPO application and publication numbers, the year of the application at the EPO, the name(s) of the applicant(s), and the patent abstract summarizing the invention.

The online questionnaire was offered in English, Czech, German, Spanish, French, Hungarian, Italian, Dutch, Polish, and Slovenian, and Japanese. For the reminder letter, we also prepared a Hebrew translation of the questionnaire, which was sent by mail to Israeli inventors. We did not offer translations for Scandinavian languages, since these countries “have the best command of English among countries where English is not the native language”.⁹ In Europe and Israel, we sent out one reminder letter and one reminder post card to increase the response rates. In the U.S. and in Japan the inventors received two reminder post cards.

We received a total of 23,044 answers. Table A1 in the paper reports 22,567 observations, which correspond to the total number of responses with non-missing information on the size of the inventor’s employer at the time of the invention - business enterprises, PRI (universities, government research organization and other government organization, private hospital, research organization or foundation, other (including individual inventors). 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%. Table A1 in the Appendix provides an overview of the response rates by country.

Our analysis focuses on inventions developed by private enterprises - 18,850 observations, for 18,628 of which we have information on the size of the employer. The basic sample of patented inventions for the purposes of this paper is then 18,628.

However, in our estimations the number of observations drops mostly because of missing values and “do not know” responses (which we coded as missing) to the questions used for building

⁹ See <http://www.reuters.com/article/2011/03/31/us-language-english-proficiency-idUSTRE72U38W20110331> (accessed on Dec. 12, 2014).

the dependent variable. Table A3 in the Appendix shows the number of observations, missing data and ‘don’t know’ responses on five questions concerning patent uses. As the table clearly shows, the 40% reduction in sample size from 18,628 to 11,290 observations is due missing data and ‘don’t know’ responses on one or more of the following uses reported by the interviewee: internal use (in new products/services or manufacturing processes), licensing, sale and creation of new firm¹⁰. Table A4 in the Appendix describes patent uses and the variable *Used* which indicates if the patent has been utilized in at least one of the aforementioned uses. After eliminating missing observations and ‘don’t know’ and combining these four types of patent use we ended up with a total number of observations for the variable *Used* of 11,290 (a 40% drop in the observations). Instead, missing values for explanatory variables are responsible for a small reduction in the sample size, from 11,290 to 10,650 observations.

We treated “don’t know” responses as missing data and deleted all cases with missing data on a specific variable (listwise deletion). We also ran the Little’s missing completely at random (MCAR) test for *blocking* and *Used*, the variables that we combine to obtain our dependent variable in the multinomial logit estimations (Little, 1988 and 1995)¹¹. The Little’s MCAR test cannot reject the assumption of randomness in missing values - Chi-square distance = 1.5150 , p-value = 0.4688 (Chi-square distance = 1.6102; p-value= 0.8070 when the assumption of equal variances between missing-value patterns is removed). The MCAR test then suggests that our data do not significantly deviate from the assumption of missing completely at random.

Our econometric analysis focuses on pending and granted patents, which implies a further reduction of the sample from 10,650 to 8,144 observations.

We excluded withdrawn and rejected patent applications because it is arguable whether these applications can block other patents or are licensed to third parties¹². Earlier works on

¹⁰ We excluded cases of pure cross-licensing, i.e. when the patent is licensed but not used internally.

¹¹ See Table A4 in the Appendix for a description of *Blocking* as a reason for patenting. As discussed later, we combined *Blocking* and *Used* to obtain different categories of patent strategies.

¹² It is worth noting that withdrawn patent applications can be used strategically to block subsequent patents because their publication by the patent office constitutes prior art (e.g., Guellec et al. 2012).

licensing draw on granted patent (e.g., Siebert 2015; Palomeras, 2007). We further include pending patent applications for two reasons. First, in our dataset pending, patents are frequently used either internally (e.g., product innovations) or externally (e.g., licensing). Thus, by dropping these applications we could introduce a sample selection bias. Moreover, there are not very strong differences in uses between pending patent applications and granted patents while they are both markedly different from rejected/withdrawn applications. Our data indicate that 62% of granted patents are used vs. 59% of pending patent applications. Pearson's chi-square test suggests that these differences are statistically significant (chi-square 6.74 significant at 1% level). However, pending patent applications are used more frequently and remain less frequently unused compared with withdrawn/rejected patent applications, which are used in only 50% of case (chi-square 49.14 significant at 1% level). Second, results on granted only patents are very similar although estimates are less precise because granted patents accounts for only about 40% of the observations¹³. Moreover, our estimates on granted and pending patents include a dummy variable for granted patents.¹⁴

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 for patenting and the uses of patents between small and large firms. Like Jung and Walsh (2014), we find that the probability of "don't

¹³ These results are available from the authors upon request.

¹⁴ It is worth to recall that the European Patent Office suggests the applicants to seek opportunities to exploit a pending patent application: "The period between filing and requesting substantive examination should be used to seek opportunities to exploit the invention. Even if your preference is a licensing agreement, it may be worth setting a date after which you plan instead for business start-up. The reason is that if no company shows interest in your idea, you do not want to reach substantive examination stage with no other option to pursue"(source: <http://www.epo.org/learning-events/materials/inventors-handbook/protection/strategy.html>).

know” increases with firm size, although the share of “don’t know” does not increase linearly with firm size. This suggests that errors in responses on patent uses may increase with firm size, but it also highlights that inventors answer the questions on patent uses if they have enough information.

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

Reasons for patenting

Table 1 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. All variables and data sources are described in the Appendix (Tables A4 and A5). Prevention of imitation and commercial exploitation (obtain exclusive rights to exploit the invention economically) are the most important reasons for patenting. Blocking competitors and pure defense have an average importance score of 3.83 and 3.39. (Cross-) licensing, reputation and the prevention of infringement suits are less important exhibiting an average importance ranging between 2.69 and 3.16. Technical standards has an average score of 1.92, 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 19% 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 large differences across technological areas. This is in line with previous studies on motives for patenting (e.g., Blind et al. 2006). 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 technologies than in other technological areas.

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

Table 1 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 2 reports the frequency of the following actual patent uses: internal use in new products/services or manufacturing processes and external use (patent sale, patent licensing, cross-licensing, and creation of a new firm) at the time of the survey¹⁵. 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 2. A blocking patent is a patent for which blocking competitors was an important reason for patenting (score of 4 or 5 to blocking competitors as a reason for patenting).

Table 2 about here

Internal use represents by far the most frequent patent use (57.6%), followed by licensing (6.4%), new firm creation (4%), and patent sale (4.3%). In total, 60.6% of the patents are used for any of these purposes while 67% of patents were filed to block competitors¹⁶.

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). Our data shows that patent sale is a quite rare event compared with other uses, including licensing. Another rare use of patents is the creation of a new firm. Table 2 shows that new firms are an equally rare event as patent sale.

As far as cross-country differences are concerned, Japan shows the largest share of unused patents (46%) compared to Europe/Israel (38%) and the U.S. (36 %), which is probably due to the lower share of granted patents. Japan also shows the highest share of blocking patents (78.8%,

¹⁵ Table A5 in the Appendix reports a detailed description of these variables. 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 2 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.

¹⁶ One may wonder what is the association between non-use and renewal fees that should be paid to keep a patent in force. Non-renewal of a patent or patent application would automatically let the patent be “deemed withdrawn” and the protected matter would then lapse into the public domain. During patent examination renewal fees paid at the EPO. Once the patent is granted, much higher fees need to be paid in the countries where the patent is validated. We do not consider patent lapses. Moreover, since we drop from our sample any applications that have been withdrawn or rejected, patents for which the applicant stops paying fees are not taken into account

compared to Europe/Israel with 63.1% and the U.S. with 65.4%). Compared to Europe/Israel, the U.S. exhibits a larger share of patents licensed (10.5% in the U.S. vs. 6.4% in Europe/Israel vs. 3.5% in Japan) and sold (7.6% in the U.S. vs. 4.2% in Europe/Israel vs. 2.2% in Japan), confirming that markets for technology are more developed in the U.S. than in Europe/Israel and Japan (Arora and Gambardella, 2010; Sheenan, 2004). New venture creation based on patents also occurs more frequently in the U.S. (6.2%) than in Europe/Israel (4.5%) or Japan (0.8%).

There are also differences across technologies in the use of patents. Internal use is more frequent in process engineering (65%) and in consumption and construction (72%). Licensing is more frequent in these two technologies, as well.

In chemicals and pharmaceuticals, nearly half of the patents remain unused 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 (70%). The share of used patents (all uses) is largest in process engineering (67%) and consumption and construction (76%). Besides chemicals and pharmaceuticals, blocking patents are most common in consumption and construction (69%), 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 internal 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 than for large firms. The large share of spinoffs spawned by or through small firms (18%) is probably due to the ‘small firm effect’, i.e. greater opportunities to develop entrepreneurial human capital offered by small firms compared with large, bureaucratic organizations (Elfenbein et al., 2010).

Finally, large firms have larger shares of unused and blocking patents in their portfolio than small or medium-sized firms. 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% and 5% level.

Dependent variable

Our investigation focuses on the combination of blocking patents as a reason 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 a value of 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* or *externally* (see Table A4 in the Appendix for a detailed description). Table 2 described above reports the shares of blocking and used patents, respectively.

The combination of *Used* and *Blocking* leads to three alternative patent uses:

Commercial use – these patent applications are used either internally or externally by the applicant, regardless of whether blocking was an important reason for patenting or not (*Used* = 1 and *Blocking* = 0 or *Blocking* = 1);

Strategic non-use - this mode of patent use involves blocking patent applications that remain unused (*Used* = 0 and *Blocking* = 1);

Sleeping patents, which denote patents filed for reasons different from blocking other parties and which are not being used (*Used* = 0 and *Blocking* = 0).

We excluded cases where blocking was an important reason for patenting and the patent was used in cross-licensing deals but not internally (e.g. a product innovation). Although these cases may be theoretically relevant because they match the notion of ‘block to play’ patent strategy, we could not include this category in our dependent variable because of the small number of observations (only 17 cases in our sample of 8,114 observations).

Table 3 describes the distribution of the three types of patent uses in our sample. As the data reported in this table clearly show, assignment of the sample patents to the three groups is mutually exclusive.

Table 3 about here

Most of the patents (60.6%) are filed for *commercial use*, irrespective of whether they are patented for blocking reasons too. One may wonder whether blocking as a reason for patenting suffice as a signal of strategic intention. We think that the answer is that filing a patent for commercial use often yields some blocking effect, as well. Moreover, blocking patents is not easily distinguishable from other reasons for patenting. For instance, blocking is highly correlated with prevention of imitation: “What we call “patent-blocking”—was almost as pervasive as the prevention of copying as a motive for patenting” (Cohen et al., 2002: 1358).

Strategic non-use, referred to as ‘block to fence’ patents in Cohen et al. (2002), amounts to 26.3% of cases.¹⁷ Finally, 13.1% of the patents in our sample are *sleeping patents*, i.e. unused patents that were not filed to block competitors.

Strategic non-use is more frequent in Japan (36%) than in the U.S. (24%) and in Europe/Israel (24%). Sleeping patents are slightly more common in Europe/Israel (14%), than in the U.S. (13%) or in Japan (10%).

¹⁷ Our measure of ‘strategic non-use’ differ from Cohen et al (2003) definition of ‘block to fence’ because our measure combines reasons for patenting and actual patent use whereas their measure builds on reasons for patenting only.

A few differences regarding the combinations of reasons for patenting and patent use also emerge across technologies. In chemicals and pharmaceuticals, the share of strategically non-used patents is the largest: 33% vs. 27% in electrical and mechanical engineering. Sleeping patents, instead, are least frequent in construction and consumption (8%) and process engineering (11%) compared to 14-15% in the other technologies.

As expected, large firms exhibit the largest share of strategic non-use (30%) and sleeping patents (14%). These shares are almost twice the shares of 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. As a measure of technological complexity, we use 30 OST-INPI technology areas of the patent. 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 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 patent applications in our sample are to be found in the areas of electrical device, engineering and energy (7%), areas analysis, measurement and control (8%) and transportation (7%). The smallest shares are to be found in nuclear engineering (0.4%) and space technology and weapons (0.5%).

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).¹⁸ 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 use the information about number of firms in the technological field of the focal patent to calculate concentration indices like the CR4 (cumulative share of the 4 largest patent holders), CR10 (cumulative share of the 10 largest patent holders), and the Herfindahl index with various levels of technological aggregation (3 and 4 digit IPC and 30 OST technology areas).

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.

As far as patent value is concerned, we employ the size of the INPADOC¹⁹ patent family (FAMSIZE), which measures the number of equivalents or patent applications directly or indirectly linked through a priority date. The literature has found that the size of a 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. 2007). Another measure of patent value used in previous works is 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. It is worth to note that economic interpretation of this variable is quite controversial. It is unclear whether the number of claims indicates patent complexity (Harhoff and Reitzig, 2004) or potential profitability (Lanjouw and Schankerman, 2004). Most likely, claims are a combination of both.

¹⁸ This is a measure of 'crowdness' adopted in earlier studies (e.g., Harhoff and Reitzig, 2004).

¹⁹ 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).

Family size on average amounts to 31 applications (min = 2; max = 5,051). The number of claims on average amounts to 16 (min = 0; max = 187).²⁰

In addition, we account for the generality of the focal patent (GENERALITY), another indicator of the economic value of patented inventions. 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).

Finally, the number of inventors listed on the patent document (N_INVENTORS), a measure of R&D costs, could be correlated with the expected value of the patent. On average, patents list 3 inventors, varying between 1 and 50 inventors.

In addition, after grant, EP patents by third parties can be opposed at the EPO within nine months of the grant date. 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 a value of 1 if an opposition had been filed against the patent at the EPO (OPPOSITION). 2% of the patents 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 number of ECLA classes amounts to 2.7 on average, varying between 1 and 48.

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 2.77 on average and varies between 0 and 32.

²⁰ The number of claims refer to the count at the time of extracting the data from the database, i.e. not at the time of patent application. 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.

Table 4 provides the descriptive statistics of all variables employed in the multiple correlation analysis. Table 5 presents the pairwise correlations of the variables described above. Correlations between variables are relatively low, indicating that collinearity of covariates should not be a concern.

Table 4 and 5 about here

Controls

We include firm level control variables in our estimates. Moreover, we control for the legal status of the application as of April 2011 with the variable GRANTED, which equals 1 when the patent is granted and zero if pending. Firm Size is measured by the number of employees. As mentioned before, the PatVal2 survey asked to assign the employer's organization to 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 70% of the firms in our sample are large firms (>500 employees). 16% of the firms have less than 100 employees.

The size of the firms' patent stock 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 litigation (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 974 patents on average and varies between 0.08 and 13,017 patents.

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

Method

After we collected the data, we computed and employed sampling weights for the multivariate analysis to ensure that our results are representative for the population of EP patents in the selected countries and years. The sampling weights were generated to account for both, coverage biases (non-random selection) and nonresponse biases (Groves, 2004). To account for coverage biases we calculated a set of weights that 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 that 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.

Patent use choice was estimated by means of a multinomial logit model:

$$Prob(Y_i=j|x_i) = \frac{\exp(x_i' \alpha_j)}{\sum_{j=1}^3 \exp(x_i' \alpha_j)}$$

where x_i is the vector of characteristics specific to each the patent-technology-firm combination, which is assumed not to vary across the three choices.

To test the independence of irrelevant alternatives (IIA) assumption, we ran a generalized Hausman test (via `suest`) because the model fitted on our data failed to meet the asymptotic assumptions of the standard Hausman test. The test reported in Table 3 failed to reject the IIA assumption in all model specifications.

4. Results

This section illustrates the results obtained from multinomial logit estimations. Table 6 shows the marginal effects of the regressors on *Commercial use*, *Strategic non-use* and *Sleeping patents*. For

reasons of space the coefficients of the multinomial logit regressions of *Strategic non-use* and *Sleeping patents* (with *Commercial* use as baseline outcome) are not reported in the paper and are available from the authors upon request.

We estimated four models. Model 1 includes the control variables and the first group of regressors capturing complexity (30 OST technological areas), Model 2 adds technological competition while Model 3 adds measures of patent value. Finally, Model 4 displays the full model with our measure of legal validity (XY_PATENT_REF).

Results reported in Table 6 are largely in line with our expectations.

Table 6 about here

Technological characteristics and competition

We start by examining the association between complexity and patent uses. In the first model of Table 6, we analyze complexity via the technology area dummies (30 OST areas). We use a discrete technological area, i.e., ‘pharmaceutical and cosmetics’, as the reference group. 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 *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 and significance level of these marginal effects are 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). We also find that a few ‘discrete’ technological areas (e.g., macromolecular chemistry) have a negative marginal effect on *Strategic Non-use* and a positive effect on *Commercial Use*. This apparently surprising result may be explained by the fact

that the technology dummies capture multiple characteristics of technologies beyond complexity. Moreover, complexity may vary within the same technology class.

The marginal effects of competition reported in Model 2 are more nuanced compared with those of technological complexity. The presence of one competitor for the patent (ONE_COMPETITOR) is positively associated with the probability of *Commercial Use* of patents and negatively associated with *Sleeping Patents*. The marginal effect of *Strategic Non-use* is not significant when all regressors are factored into the model. This suggests that patent holders facing competition are more likely to rely on patents - either to protect their innovation or to ensure freedom to operate through licensing.

Interestingly, the marginal effect of more than one competitor (SEVERAL_COMPETITORS) on *Commercial Use* is not statistically significant while the effect on *Sleeping Patents* remains negative and significant. On the contrary, the marginal effect on *Strategic Non-use* of several competitors is positive, which suggests that a large number of competitors (intense technological competition) spurs firms to accumulate patent fences.

We 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). The marginal effect of this variable is never significant. 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 non-use). Instead, a large number of patent holders (IPC4_NFIRMS) proxies for a broader dimension of the technological environment, that is the dispersion of patent rights. As such, a large number of patent holders generates contrasting effects that probably cancel each other out. For instance, the presence of other patent holders in the same technological field may spur the commercial use of patents. However, a high risk of holdup and transaction costs hampers commercial use.

Patent value and legal validity

We used numerous measures of patent value or importance. FAMILY_SIZE is negatively associated to *Sleeping Patents* while it is not correlated with *Commercial Use and Strategic Non-use*. This suggests that more valuable patents are less likely to remain *Sleeping*, although their use in the market or as strategic weapon is not clear.

TOT_ECLA are never significant while CLAIMS are negatively related with *Commercial Use* and positively associated with sleeping patents, albeit the marginal effect is not always significant. GENERALITY is also negatively related with *Commercial Use* and positively related with *Sleeping Patents*, which probably indicates the substantial adaptation costs that general-purpose technologies require to be used in different application contexts. These results thus suggest that patents with a broad technological scope (GENERALITY) and protection scope (CLAIMS) may be difficult to exploit both in the market for products and in the market for patents (licensing and sale).

The marginal effects of N_INVENTORS are positive and significant for *Commercial Use*, similarly to other measures of patent value, and negative and significant for *Strategic Nonuse*.

As mentioned before, received oppositions measure the value or the uncertain validity of the patent. Our results show that the effect of OPPOSITION on patent use are not significant in our empirical setting.

The marginal effects of XY_PATENT_REF, our proxy for legal validity, on *Commercial Use* are insignificant. Instead, the effects on *Strategic Non-use* are positive and significant while the effects on *Sleeping Patents* are negative. These results then suggest that patents of uncertain validity are taken for strategic reasons, e.g., preempting competitors (Gilbert and Newbery, 1982).

Controls

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*. However, the effect of very large firms (more than 1000 employees) compared with SMEs (1 to 249 employees) is not significant on *Strategic Non-use*, which suggests that both types of firms have reasons to prevent others patents. For instance, a small firm may file a patent application to prevent the grant of rival patents and avoid the risk hold-up rather than protecting an invention used in the market (Guellec et al. 2012). We also find that the marginal effect of very large firms compared to SMEs is positive and significant on *Sleeping Patents*, 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, with a larger and more significant effect on *Strategic Non-use* than on *Sleeping Patents*.

The country dummies confirm that European applicants tend to have more *Sleeping Patents* and less *Commercial Use* compared to their U.S. counterparts. Instead, Japanese applicants have less *Commercial Patents* and more *Strategic Non-use* compared with U.S. applicants.

Among controls, we include GRANTED patents. We do not find any significant relationship between granted (vs. pending) patents and *Commercial Use or Sleeping Patents*, while granted patents are less likely to be associated with *Strategic Non-use*.

Robustness checks

We run various additional estimations in order to check for the robustness of our results. First, to further check for any effect of missing observations in our estimations, in unreported regressions we assumed that “don’t know” equals “no”. Table A3 in the Appendix shows that “don’t know” responses are not uniformly distributed across items (licensing and sales have particularly large shares of “don’t know”), which suggests that inventors are more informed about some uses than others. If the inventor answered only to the items she was informed about, “don’t know” answers cannot be interpreted as “no”. Thus, rather than assuming that all ‘don’t know’ equal ‘no’, we made this assumption under conditions. A new version of *Commercial use* was

generated as follows. We coded as missing only the observations for which the answers about all four patent uses were missing or “don’t know”. Instead, we coded as ‘no’ all missing and “don’t know” responses where the inventor responded to at least one of the questions on patent uses (e.g., use in a new product, service or in a manufacturing process). We followed the same procedure with the questions on motivations for patenting, including blocking patents. The new definition of *used* and *blocking* led to a final sample of 12,554 observations. As a robustness check, we ran our multinomial logit regressions with the new version of the dependent variables. The estimates based on this larger sample yield very similar results (there are only a few changes in the level of significance of some variables). Results are available upon request from the authors.

Second, to explore the association between complexity and patent use further, we used a second measure of technological complexity, which draws on mutually critical (X or Y) references 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 signal more complexity and transaction costs in the market for technology (Harhoff et al. 2015).

The results available upon request from the authors show that the marginal effects on the three patent ‘uses’ are never significant. We should note that the number of triples is calculated at a relatively high level of aggregation (the 30 OST areas). It is likely then that heterogeneity within each of the thirty technology fields attenuates the marginal effects of the triples measure on patent use.

In alternative estimations, we also control for the concentration ratio (top 4, top 8 or top 10 patent applicants) or the Herfindahl index of the IPC4-digit, IPC-3 digit or OST technological classes. None of these indicators exhibit significant relations with use and non-use, suggesting that

with high levels of aggregations it is difficult to control for the effect of intensity of technological competition on the use or strategic behavior of the company.

To better understand institutional differences across countries, in unreported estimations available upon request from the authors we run separate estimations for the sample of Europe and Israel, U.S. and Japan. Results overall are confirmed in all estimations. However, some differences should be highlighted. In particular, the marginal effects of firm size on *Strategic Non-use* is significant in European companies, while there are only slightly significant differences in the use of patents and *Strategic Non-use* across firms of different size classes in the U.S. and Japan. By contrast, the difference across technological classes are significant in the U.S. case, and much less so in the other countries, suggesting that technology-specific characteristics like complexity are probably more relevant in the US, where domestic companies occupy top market positions in several complex industries like IT and semiconductors.

Finally, as mentioned before, in unreported regressions we estimated our multinomial models with granted only patents. Results are similar to those reported in the paper although estimates are less precise because granted patents accounts for only about 40% of observations.

5. Summary and conclusions

This paper employs data from the PatVal2 survey conducted in 2009-2011 and containing data for a sample of inventor-invention pairs in Europe, Israel, Japan and the U.S. The aim of the survey was to provide novel evidence about the characteristics of the inventive process leading to patent applications filed at the EPO. We collected information about the patent, the inventor's profile, the size and other employer features, and external environment conditions such as the number of patent holders in the same technology area and the presence of competitors for the patent. The analysis in this paper focuses on 'blocking' as a reason for patenting and 'patent use'.

The main results of the analysis are robust to various checks and can be summarized as follows. First, a substantial share of patents remained unused (~40%) and about 68% of patent applications

were filed to block other patents. Large firms are more likely than smaller firms to have unused patents in their portfolio. The large share of strategic non-use (blocking unused patents), especially among larger firms, is consistent with the importance of strategic reasons for patenting shown by the holders of large patent portfolios.

We also find important cross-technology and cross-country differences. Japan exhibits a larger share of unused patents (particularly strategic non-use), and the U.S. is characterized by a larger share of patents licensed, cross-licensed or sold. These results are consistent with the view that markets for technology presumably are more developed in the U.S. than in Europe, possibly due to the stronger threat of litigation in the U.S.

Our multivariate analysis shows that patent use varies significantly between complex technologies, like electrical machinery, electrical energy, audiovisual technology and information technology on the one hand, and discrete technologies like pharmaceuticals and cosmetics on the other hand (Cohen et al., 2002; von Graevenitz et al., 2013). Patents in complex technologies are more likely to be used 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 discrete product industries like pharmaceuticals and chemicals are more likely to patent several substitutes for core inventions with the aim of preempting competition ('fence strategy').

Second, we find a positive association between patent use and the presence of competitors for the patent during the inventive process. However, the effect of competition is not significant in the presence of several competitors. Instead, a large number of competitors for the patent increases the likelihood of strategic patenting (strategic non-use). These findings are consistent with previous studies that have found a positive association between defensive or offensive blocking motives and intensity of competition (e.g., Blind et al. 2006). The nuanced effects of competition point at the presence of contrasting forces at work. Whereas competition spurs innovators to use their patents in

commerce, a large number of competitors stimulates the adoption of sophisticated patenting strategies aiming at blocking competing patents (i.e., patent barriers that protect alternative solutions to similar technical problems) rather than protecting new products or processes used in commerce. 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 does not exhibit any significant effects.

Third, we used various measures of patent value like patent family size, the number of inventors, the incidence of opposition, generality and number of claims. Family size is negatively associated with *Sleeping patents* whereas the number of inventors is positively associated with *Commercial use* and negatively with *Strategic non-use*. These findings are not surprising since the size of inventor team and family size proxy for the inventive costs and the patenting costs, respectively.

As expected, patents with relatively many X and Y references (a proxy for uncertain validity) are more likely to remain unused for strategic reasons.

Finally, the likelihood of commercial use decreases with firm size and the size of its patent portfolio, while the likelihood of strategic non-use increases. This confirms that the owners of large patent portfolios often use patents to preempt competition. The positive association between firm size (and the size of patent portfolio) and sleeping patents point at some inefficiency in the management of intellectual property by large firms which may be due to inability to recognize the business opportunities of valuable patents or the accumulation of low-value patents for purely defensive purposes (Rivette and Kline, 2000).

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. Our analysis points to several complex interactions among firm-, patent- and technology-specific conditions that future research should investigate in order to put patenting in a broader context of firm's competitive strategy. We also 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. Moreover, future research should adopt a longitudinal perspective and collect information from different key informants besides inventors. Furthermore, while the strategic non-use of patents is conceivably welfare-reducing, an exact welfare assessment is not available at this point - more theoretical and empirical research is needed to arrive at unambiguous conclusions. Our characterization of contexts in which the incidence of strategic use and non-use of patents is particularly high should be helpful in achieving such progress.

A further exploration of antecedents and consequences of unused patents is important for future research and public policy focusing on 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. Unused patents need closer scrutiny, for example by looking at their blocking effect traced by X and Y type citations received or the outcome of patent litigation

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. Thus, their overall impact needs to be scrutinized further. Moreover, while patent law in some countries, like the UK or Germany, allows for compulsory licensing under certain conditions, the requirements are difficult to fulfill. This turns compulsory licenses into an exceptional and hard-to-use instrument. In other countries, like the U.S., compulsory licensing, especially for pharmaceutical patents, is being debated (e.g., Epstein and Kieff, 2011).

Our analysis clearly shows that a significant share of patents are sleeping patents, i.e., they are unused for reasons different than blocking. According to some scholars (Weeds, 1999), sleeping patents may protect an early stage invention whose development and commercialization require irreversible investments that the owners could undertake if technological or market conditions are favorable. These patents then have an option value that compulsory licensing would destroy with negative consequences for the ex-ante private incentives to invest in multi-stage research projects. To stimulate more intense exploitation of sleeping patents that protect early stage inventions, there exist alternatives to compulsory licensing such as the license of right provisions, which grants a reduction on the renewal fees if the patentee voluntarily allows any third party to use the patent in return for a reasonable compensation. In Germany license of right is declared for about 6% of all granted applications (Rudyk 2012), and for between 10% and 20% of patents in electrical engineering.

A systematic examination of the impact of license of right on the market for patents in different countries would be useful for a better understanding of the private incentive to participate in this market. However, 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, are debated amongst scholars, practitioners and policy-makers interested in understanding how a more intense use of unused

patents can be stimulated 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 European Commission has recently produced a report (European Commission, 2012) in which it seeks to explore the reasons why many patents are not used and the actions that policy makers can take to foster a more efficient use of intellectual property. 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.

Finally, IP policies could complement market-building policies. The strengthening of patent protection that occurred since the 1980s has favored the reallocation of patent rights, specialization and the formation of a market for access to technology (Serrano, 2008). However, excessive patent scope and low barriers to patentability (i.e. novelty and inventive step requirements) increase the likelihood of low patent quality and of overlapping IP rights, thus giving rise to patent fences and patent thickets. The role of IP policy is then necessarily complex and should be more closely coordinated with competition policy. Thus, policy tools should emphasize the application of a stringent inventive step criterion in patent examination and post-grant reviews, and should discourage the emergence of patent filings that aim largely at creating strategic defenses and barriers to entry for newcomers.

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

	Commercial exploitation	Licensing	Cross licensing	Prevention of Imitation	Blocking patents	Reputation	Prevention of infringement suits	Pure defense	Technical standards
Total	4.37	2,96	2,69	4,13	3,83	2,85	3,16	3,39	1,92
EU + Israel	4,30	2,87	2,51	4,12	3,70	3,03	3,00	3,25	2,04
U.S.	4,47	2,93	2,57	4,10	3,77	3,27	3,16	3,16	1,90
Japan	4,46	3,24	3,23	4,18	4,20	2,08	3,57	3,93	1,74
multivariate test on means	***	***	***	**	***	***	***	***	n.s.
Electrical engineering	4.15	3.02	3.17	4.01	3.72	2.89	3.34	3.51	2.02
Instruments	4.41	2.88	2.75	4.14	3.80	2.93	3.22	3.36	1.74
Chemicals and ggPharmaceuticals	4.56	3.14	2.62	4.07	3.90	2.76	3.04	3.32	1.94
Process engineering	4.38	2.82	2.44	4.25	3.85	2.81	3.10	3.39	1.90
Mechanical engineering	4.31	2.96	2.59	4.11	3.82	2.79	3.08	3.38	1.85
Consumption and Construction	4.52	2.84	2.14	4.38	3.93	3.03	3.16	3.34	2.31
multivariate test on means	***	***	***	***	***	***	***	**	n.s.
Small firms [<100 empl.]	4.57	3.53	2.30	4.22	3.62	3.19	3.09	3.30	2.38
Medium sized firm [100- 249 empl.]	4.45	2.76	2.17	4.23	3.74	2.96	3.06	3.27	1.53
Large firm [>=250 empl.]	4.32	2.86	2.80	4.10	3.87	2.78	3.18	3.42	1.83
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 30 and 8,144 depending on the subsample.

Table 2. Uses of patents: Share of total patents.

	Commercial Use of the patent	Patent sale	Patent licensing	Start-up	Used patent	Blocking patent
Total	0.576	0.043	0.064	0.040	0.606	0.670
EU + Israel	0.590	0.042	0.064	0.045	0.620	0.631
U.S.	0.591	0.076	0.105	0.062	0.640	0.654
Japan	0.530	0.022	0.035	0.008	0.541	0.788
multivariate test on means	***	***	***	***	***	***
Electrical engineering	0.567	0.039	0.068	0.035	0.596	0.650
Instruments	0.557	0.057	0.058	0.053	0.590	0.664
Chemicals and Pharmaceuticals	0.489	0.044	0.067	0.029	0.529	0.696
Process engineering	0.646	0.047	0.082	0.041	0.669	0.665
Mechanical engineering	0.571	0.031	0.040	0.027	0.591	0.665
Consumption and Construction	0.723	0.053	0.090	0.081	0.758	0.694
multivariate test on means	***	**	***	***	***	**
Small firms [<100 empl.]	0.660	0.122	0.167	0.179	0.765	0.615
Medium sized firm [100-249 empl.]	0.739	0.043	0.086	0.056	0.770	0.653
Large firm [\geq 250 empl.]	0.548	0.027	0.042	0.010	0.562	0.682
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 444 and 8144 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 3. Used and unused patents: Share of total patents.

	Commercial use [Used=1&Blocking=0 or Blocking=1]	Strategic non-use [Used=0&Blocking=1]	Sleeping patents [Used=0&Blocking=0]
Total	0.606	0.263	0.131
EU + Israel	0.620	0.236	0.144
U.S.	0.640	0.235	0.125
Japan	0.541	0.358	0.101
multivariate test on means	***	***	***
Electrical engineering	0.596	0.268	0.135
Instruments	0.590	0.266	0.145
Chemicals and Pharmaceuticals	0.529	0.326	0.145
Process engineering	0.669	0.223	0.108
Mechanical engineering	0.591	0.268	0.142
Consumption and Construction	0.758	0.164	0.078
multivariate test on means	***	***	***
Small firms [<100 empl.]	0.765	0.145	0.090
Medium sized firm [100-249 empl.]	0.770	0.155	0.074
Large firm [>=250 empl.]	0.562	0.295	0.143
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 444 and 8144 depending on the subsample.

Table 4. Descriptive statistics (N. 8,144)

Variable	Mean	S.D.	Median	Min	Max
BLOCKING	0.67		1	0	1
USED	0.61		1	0	1
COMMERCIAL USE	0.61		1	0	1
STRATEGIC NON-USE	0.26		0	0	1
SLEEPING PATENTS	0.13		0	0	1
IPC4_NFIRMS	6993,95	7003,28	4542	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	2.77	2.87	2	0	32
TOT_ECLA	2.71	2.03	2	1	21
CLAIMS	16.36	11.88	13	0	187
FAMSIZE	30.58	61.71	34	2	5051
NR_INVENTORS	2.57	1.88	2	1	50
GENERALITY	0.08	0.18	0	0	0.86
DUMMY_MISSING_GENERALITY	0.40		0	0	1
<100 EMPLOYEES	0.16		0	0	1
100-249 EMPLOYEES	0.05		0	0	1
250-499 EMPLOYEES	0.05		0	0	1
500-999 EMPLOYEES	0.05		0	0	1
1000-4999 EMPLOYEES	0.14		0	0	1
>5000 EMPLOYEES	0.55		1	0	1
PATENT_STOCK	973,92	2133,94	1577761	0,08	13017
PRIORITY_YEAR 2003	0.31		0	0	1
PRIORITY_YEAR 2004	0.38		0	0	1
PRIORITY_YEAR 2005	0.31		0	0	1
PENDING	0.50		0	0	1
GRANTED	0.50		1	0	1
COUNTRIES EU	0.61		1	0	1
COUNTRY JP	0.22		0	0	1
COUNTRY IL	0.00		0	0	1
COUNTRY US	0.16		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	0.22		0	0	1
CONSTRUCTION AND CONSUMER GOODS	0.08		0	0	1

Table 4. Descriptive statistics *continued* (N= 8144)

Variable	Complex/ Discrete	Mean	S.D.	Median	Min	Max
EL_DEV_ENGIN_ENERGY	Complex	0.07		0	0	1
AUDIO_VISUAL	Complex	0.02		0	0	1
TELECOM	Complex	0.05		0	0	1
INFORMATION TECH	Complex	0.05		0	0	1
SEMICONDUCTORS	Complex	0.02		0	0	1
OPTICS	Complex	0.02		0	0	1
ANAL_MEASUR_CONTROL_TECH	Complex	0.08		0	0	1
MEDICAL_TECH	Complex	0.05		0	0	1
NUCLEAR_ENG	Complex	0.00		0	0	1
ORG_CHEMISTRY	Discrete	0.04		0	0	1
MACROMOL_CHEMISTRY_POLYMERS	Discrete	0.03		0	0	1
PHARMA_COSMETICS	Discrete	0.03		0	0	1
BIOTECHNOLOGY	Discrete	0.01		0	0	1
AGRICULTURE_FOOD_CHEM	Discrete	0.01		0	0	1
CHEM_PETROL_BASIC_MAT_CHEMISTRY	Discrete	0.02		0	0	1
SURFACE_TECH_COATING	Discrete	0.02		0	0	1
MATERIALS_METALLURGY	Discrete	0.02		0	0	1
CHEMICAL_ENG	Discrete	0.03		0	0	1
MAT_PROCESSING_TEXTILES_PAPER	Discrete	0.04		0	0	1
HANDLING_PRINTING	Discrete	0.05		0	0	1
AGRIC_FOOD_PROC_MACH	Discrete	0.01		0	0	1
ENVIRONM_TECH	Complex	0.01		0	0	1
MACHINE_TOOLS	Complex	0.03		0	0	1
ENGINES_PUMPS_TURBINES	Complex	0.04		0	0	1
THERMAL_PROC_APPAR	Complex	0.02		0	0	1
MECHANICAL_ELEMENTS	Complex	0.05		0	0	1
TRANSPORT	Complex	0.07		0	0	1
SPACE_TECHNOLOGY_WEAPONS	Complex	0.01		0	0	1
CONSUMER_GOODS_EQUIP	Complex	0.04		0	0	1
CIVIL_ENG_BUILD_MINING	Complex	0.04		0	0	1

Table 5. Pairwise correlations (N = 8,144)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1 COMMERCIAL USE	1.000																			
2 STRATEGIC NON-USE	-0.741*	1.000																		
3 SLEEPING PATENTS	-0.481*	-0.232*	1.000																	
4 IPC4_NFIRMS	-0.040*	0.033*	0.016	1.000																
5 ONE_COMPETITOR	0.038*	-0.023	-0.025	0.010	1.000															
6 SEVERAL_COMPETIT	-0.055*	0.096*	-0.045*	0.014	-0.169*	1.000														
7 D_MISS_COMPETITOR	-0.034*	0.028	0.012	-0.014	-0.106*	-0.223*	1.000													
8 OPPOSITION	0.026	-0.014	-0.021	-0.022	0.020	-0.030*	-0.007	1.000												
9 XY_PATENT_REF	-0.002	0.022	-0.025	0.064*	0.015	0.064*	-0.015	-0.043*	1.000											
10 TOT_ECLA	-0.056*	0.054*	0.011	0.067*	0.012	0.071*	-0.033*	0.012	0.145*	1.000										
11 CLAIMS	-0.004	-0.007	0.015	0.151*	0.007	-0.051*	-0.032*	-0.007	0.130*	0.087*	1.000									
12 FAMSIZE	0.011	0.000	-0.015	0.068*	0.013	-0.046*	-0.008	0.011	0.102*	0.012	0.108*	1.000								
13 NR_INVENTORS	-0.042*	0.040*	0.009	0.099*	0.016	0.090*	0.008	-0.014	0.071*	0.090*	0.147*	0.056*	1.000							
14 GENERALITY	-0.037*	0.020	0.026	0.075*	0.017	0.017	-0.003	0.013	0.096*	0.151*	0.155*	0.057*	0.107*	1.000						
15 D_MISS_GENERALITY	0.014	-0.026	0.014	-0.049*	-0.008	-0.044*	-0.008	-0.025	-0.107*	-0.108*	-0.124*	-0.028	-0.112*	-0.357*	1.000					
16 <100 EMPLOYEES	0.142*	-0.117*	-0.053*	0.035*	-0.005	-0.112*	-0.029*	0.000	0.015	-0.018	0.066*	0.041*	-0.164*	-0.005	0.037*	1.000				
17 100-249 EMPLOYEES	0.081*	-0.059*	-0.040*	0.006	0.003	-0.027	-0.017	-0.008	-0.001	-0.027	0.025	0.011	-0.045*	-0.016	0.037*	-0.105*	1.000			
18 250-499 EMPLOYEES	0.035*	-0.023	-0.021	-0.027	0.019	-0.026	0.002	0.009	-0.015	-0.029*	-0.018	-0.006	-0.037*	-0.013	0.004	-0.096*	-0.053*	1.000		
19 500-999 EMPLOYEES	0.029*	-0.005	-0.036*	-0.014	0.001	-0.034*	0.027	-0.002	-0.015	-0.013	0.013	0.001	-0.022	-0.019	-0.011	-0.101*	-0.056*	-0.051*	1.000	
20 1000-4999 EMPL	0.020	-0.011	-0.014	0.007	0.000	0.048*	0.023	0.010	-0.005	-0.016	-0.034*	-0.016	0.008	-0.004	0.003	-0.175*	-0.096*	-0.088*	-0.093*	1.000
21 >5000 EMPLOYEES	-0.183*	0.132*	0.092*	-0.016	-0.006	0.088*	0.001	-0.007	0.006	0.054*	-0.035*	-0.022	0.161*	0.027	-0.043*	-0.483*	-0.266*	-0.244*	-0.257*	1.000
22 PATENT_STOCK	-0.092*	0.048*	0.070*	-0.010	-0.008	0.001	0.008	-0.001	-0.040*	-0.005	-0.053*	-0.038*	0.078*	0.000	0.001	-0.185*	-0.095*	-0.079*	-0.092*	1.000
23 EU	0.039*	-0.080*	0.048*	-0.132*	0.018	-0.356*	0.031*	0.079*	-0.147*	-0.090*	-0.071*	0.008	-0.157*	-0.089*	0.091*	0.121*	0.057*	0.057*	0.040*	1.000
24 JP	-0.071*	0.115*	-0.048*	0.027	-0.001	0.494*	0.014	-0.057*	0.099*	0.071*	-0.176*	-0.096*	0.112*	0.016	-0.041*	-0.195*	-0.083*	-0.030*	-0.034*	1.000
25 IL	-0.011	0.017	-0.006	0.037*	-0.002	-0.010	0.013	-0.010	0.012	0.035*	0.039*	0.006	0.021	0.018	-0.022	0.049*	0.012	-0.004	-0.005	1.000
26 US	0.031*	-0.029*	-0.008	0.139*	-0.022	-0.088*	-0.059*	-0.038*	0.080*	0.033*	0.288*	0.097*	0.078*	0.097*	-0.071*	0.053*	0.017	-0.041*	-0.014	1.000

	20	21	22	23	24	25	26
20 1000-4999 EMPL	1.000						
21 >5000 EMPLOYEES	-0.443*	1.000					
22 PATENT_STOCK	-0.143*	0.352*	1.000				
23 EU	-0.073*	-0.106*	0.027	1.000			
24 JP	0.134*	0.116*	-0.003	-0.675*	1.000		
25 IL	-0.007	-0.032*	0.007	-0.077*	-0.033*	1.000	
26 US	-0.055*	0.014	-0.035*	-0.548*	-0.236*	-0.027	1.000

Note: * $p < 0.10$.

Table 6. Multinomial logit estimation. Average Marginal Effects

	COMMERCIAL USE				STRATEGIC NON USE				SLEEPING PATENTS			
	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4
ONE_COMPETITOR		0.080***	0.080***	0.078***		-0.037**	-0.037*	-0.035*		-0.043***	-0.043***	-0.043***
		0.022	0.022	0.022		0.021	0.021	0.020		0.016	0.016	0.016
SEVERAL_COMPETITORS		0.010	0.010	0.009		0.027*	0.027**	0.029**		-0.037***	-0.037***	-0.037***
		0.016	0.016	0.016		0.015	0.014	0.013		0.012	0.012	0.012
IPC4_NFIRMS		-0.007	-0.007	-0.006		0.006	0.005	0.005		0.001	0.001	0.002
		0.007	0.007	0.007		0.007	0.007	0.007		0.005	0.005	0.005
FAMSIZE			0.013	0.020*			0.018	0.008			-0.031***	-0.028***
			0.016	0.012			0.019	0.013			0.006	0.006
RINV			0.009***	0.009***			-0.006**	-0.006**			-0.003	-0.003
			0.003	0.003			0.003	0.003			0.002	0.002
TOT_ECLA			-0.009	-0.009			0.008	0.008			0.000	0.001
			0.010	0.010			0.010	0.009			0.006	0.006
CLAIMS			-0.029***	-0.027**			0.014	0.011			0.015**	0.016**
			0.011	0.011			0.010	0.010			0.008	0.008
GENERALITY			-0.099***	-0.089***			0.052	0.038			0.047**	0.051**
			0.035	0.032			0.034	0.030			0.022	0.022
OPPOSITION			0.072*	0.070*			-0.011	-0.008			-0.061*	-0.062**
			0.042	0.042			0.037	0.036			0.032	0.032
XY_PATENT_REF				-0.004				0.007**				-0.003**
				0.003				0.003				0.001
100-249 EMPLOYEES	0.012	0.012	0.011	0.012	-0.003	-0.004	-0.001	-0.002	-0.009	-0.007	-0.011	-0.010
	0.031	0.031	0.031	0.031	0.030	0.030	0.031	0.030	0.025	0.025	0.025	0.025
250-499 EMPLOYEES	-0.075**	-0.076**	-0.078*	-0.077**	0.047	0.048	0.052*	0.050*	0.028	0.028	0.026	0.027
	0.032	0.032	0.032	0.031	0.031	0.031	0.031	0.030	0.024	0.024	0.024	0.023
500-999 EMPLOYEES	-0.081***	-0.078**	-0.081***	-0.081***	0.094***	0.092***	0.096***	0.097***	-0.014	-0.014	-0.015	-0.015
	0.031	0.031	0.031	0.031	0.029	0.029	0.028	0.028	0.025	0.025	0.025	0.025
1000-4999 EMPLOYEES	-0.080***	-0.078***	-0.081***	-0.080***	0.039*	0.038	0.042**	0.041*	0.041**	0.040**	0.039**	0.039**
	0.024	0.024	0.024	0.024	0.024	0.024	0.023	0.023	0.017	0.017	0.017	0.017

Table 6. cont.

	COMMERCIAL USE				STRATEGIC NON USE				SLEEPING PATENTS			
	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4
>5000 EMPLOYEES	-0.119***	-0.118***	-0.120***	-0.118***	0.067***	0.066***	0.067***	0.064***	0.052***	0.052***	0.053***	0.054***
	0.024	0.024	0.024	0.023	0.025	0.025	0.024	0.024	0.017	0.017	0.017	0.017
PATENT_STOCK	-0.023***	-0.023***	-0.024***	-0.024***	0.019***	0.018***	0.020***	0.020***	0.004*	0.004*	0.004	0.004
	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.002	0.002	0.002	0.002
GRANTED	0.018	0.019	0.015	0.010	-0.026**	-0.026**	-0.023**	-0.015	0.008	0.007	0.009	0.005
	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011	0.008	0.009	0.009	0.009
EL_DEV_ENGIN_ENERGY	0.228***	0.215***	0.222***	0.208***	-0.165**	-0.153**	-0.126**	-0.109**	-0.063*	-0.061*	-0.096***	-0.099***
	0.068	0.068	0.055	0.050	0.078	0.078	0.049	0.043	0.033	0.035	0.032	0.032
AUDIO_VISUAL	0.249***	0.236***	0.247***	0.231***	-0.238***	-0.226***	-0.202***	-0.181***	-0.011	-0.010	-0.045	-0.049
	0.076	0.076	0.065	0.060	0.086	0.087	0.062	0.056	0.040	0.041	0.038	0.038
TELECOM	0.193***	0.188***	0.207***	0.187***	-0.221***	-0.214***	-0.193***	-0.166***	0.027	0.027	-0.014	-0.021
	0.071	0.070	0.057	0.050	0.079	0.080	0.050	0.041	0.031	0.033	0.029	0.029
INFORMATION TECH	0.234***	0.231***	0.242***	0.220***	-0.196**	-0.191**	-0.163***	-0.135***	-0.038	-0.040	-0.078***	-0.085***
	0.071	0.071	0.056	0.049	0.082	0.082	0.052	0.043	0.033	0.034	0.031	0.031
SEMICONDUCTORS	0.139*	0.129*	0.143**	0.127**	-0.142**	-0.136	-0.111**	-0.092*	0.003	0.006	-0.032	-0.035
	0.076	0.075	0.063	0.058	0.084	0.084	0.056	0.050	0.041	0.042	0.039	0.039
OPTICS	0.189***	0.175**	0.190***	0.175***	-0.195**	-0.184**	-0.160***	-0.140***	0.006	0.009	-0.031	-0.035
	0.072	0.072	0.059	0.054	0.082	0.082	0.055	0.048	0.037	0.039	0.036	0.036
ANAL_MEASUR_CONTROL_TECH	0.175***	0.167**	0.177***	0.160***	-0.190**	-0.181**	-0.154***	-0.131***	0.015	0.015	-0.024	-0.028
	0.068	0.067	0.054	0.048	0.078	0.078	0.048	0.041	0.030	0.032	0.028	0.028
MEDICAL_TECH	0.156**	0.151**	0.150***	0.134***	-0.125	-0.122	-0.094*	-0.075*	-0.031	-0.029	-0.057*	-0.060*
	0.069	0.068	0.055	0.048	0.080	0.080	0.051	0.043	0.033	0.035	0.031	0.031
NUCLEAR_ENG	0.093	0.068	0.065	0.048	-0.066	-0.041	-0.012	0.009	-0.027	-0.027	-0.053	-0.057
	0.088	0.091	0.083	0.078	0.091	0.093	0.072	0.065	0.054	0.057	0.055	0.054
ORG_CHEMISTRY	-0.007	-0.016	-0.023	-0.045	-0.042	-0.038	-0.017	0.012	0.049	0.055	0.040	0.033
	0.072	0.071	0.062	0.053	0.079	0.078	0.056	0.043	0.032	0.033	0.029	0.030
MACROMOL_CHEMISTRY_POLYMERS	0.227***	0.214***	0.217***	0.201***	-0.147*	-0.137	-0.116**	-0.096**	-0.080*	-0.077*	-0.101**	-0.105***
	0.073	0.071	0.061	0.054	0.083	0.083	0.057	0.049	0.041	0.043	0.040	0.039

Table 6. cont.

	COMMERCIAL USE				STRATEGIC NON USE				SLEEPING PATENTS			
	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4
BIOTECHNOLOGY	0.090	0.082	0.085	0.064	-0.121	-0.118	-0.097	-0.070	0.031	0.036	0.012	0.006
	0.081	0.080	0.071	0.064	0.087	0.087	0.066	0.057	0.040	0.041	0.038	0.038
AGRICULTURE_FOOD_CHEM	0.291***	0.277***	0.272***	0.255***	-0.265***	-0.253***	-0.231***	-0.211***	-0.026	-0.025	-0.041	-0.044
	0.081	0.082	0.073	0.068	0.092	0.093	0.072	0.066	0.050	0.051	0.049	0.049
CHEM_PETROL_BASIC_MAT_CHEMISTRY	0.139*	0.122	0.123*	0.109*	-0.092	-0.080	-0.060	-0.044	-0.047	-0.042	-0.062	-0.065
	0.074	0.074	0.064	0.058	0.083	0.083	0.059	0.050	0.041	0.043	0.040	0.040
SURFACE_TECH_COATING	0.234***	0.221***	0.233***	0.216***	-0.225***	-0.215**	-0.194***	-0.173***	-0.009	-0.006	-0.039	-0.043
	0.079	0.078	0.067	0.061	0.087	0.086	0.060	0.053	0.040	0.042	0.038	0.038
MATERIALS_METALLURGY	0.214***	0.196***	0.204***	0.188***	-0.182**	-0.168**	-0.148***	-0.127***	-0.032	-0.028	-0.057	-0.061*
	0.073	0.073	0.061	0.056	0.082	0.082	0.056	0.049	0.036	0.039	0.036	0.036
CHEMICAL_ENG	0.256***	0.244***	0.254***	0.237***	-0.203**	-0.195**	-0.174***	-0.153***	-0.053	-0.049	-0.079**	-0.084**
	0.072	0.071	0.059	0.053	0.081	0.081	0.054	0.046	0.036	0.037	0.033	0.033
MAT_PROCESSING_TEXTILES_PAPER	0.177***	0.160**	0.167***	0.151***	-0.161**	-0.146*	-0.125**	-0.106**	-0.017	-0.014	-0.042	-0.045
	0.068	0.068	0.056	0.049	0.078	0.079	0.051	0.043	0.032	0.035	0.031	0.031
HANDLING_PRINTING	0.282***	0.272***	0.276***	0.260***	-0.237***	-0.225***	-0.199***	-0.180***	-0.046	-0.047	-0.077**	-0.080***
	0.068	0.067	0.054	0.048	0.078	0.078	0.050	0.043	0.032	0.034	0.030	0.030
AGRIC_FOOD_PROC_MACH	0.214**	0.198**	0.195**	0.180**	-0.115	-0.102	-0.070	-0.052	-0.099*	-0.096	-0.125**	-0.128**
	0.091	0.091	0.083	0.079	0.090	0.090	0.070	0.064	0.057	0.059	0.057	0.057
ENVIRONM_TECH	0.285***	0.274***	0.281***	0.267***	-0.251***	-0.242***	-0.216***	-0.201***	-0.035	-0.033	-0.065	-0.066
	0.083	0.084	0.074	0.070	0.092	0.092	0.070	0.065	0.045	0.047	0.046	0.045
MACHINE_TOOLS	0.318***	0.303***	0.309***	0.294***	-0.266***	-0.253***	-0.225***	-0.206***	-0.052	-0.051	-0.083**	-0.087**
	0.073	0.073	0.062	0.057	0.082	0.083	0.056	0.051	0.038	0.041	0.038	0.038
ENGINES_PUMPS_TURBINES	0.150**	0.131*	0.137**	0.123**	-0.118	-0.101	-0.070	-0.053	-0.032	-0.030	-0.067**	-0.070**
	0.070	0.071	0.058	0.053	0.079	0.080	0.050	0.044	0.032	0.036	0.033	0.033
THERMAL_PROC_APPAR	0.232***	0.215***	0.220***	0.207***	-0.203**	-0.188**	-0.165***	-0.150***	-0.028	-0.027	-0.055	-0.057
	0.073	0.073	0.062	0.057	0.083	0.084	0.059	0.053	0.038	0.041	0.038	0.038
MECHANICAL_ELEMENTS	0.196***	0.182***	0.188***	0.175***	-0.205***	-0.191**	-0.161***	-0.146***	0.009	0.009	-0.028	-0.030
	0.069	0.068	0.054	0.049	0.079	0.079	0.050	0.044	0.031	0.034	0.031	0.030

Table 6. cont.

	COMMERCIAL USE				STRATEGIC NON USE				SLEEPING PATENTS			
	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4	Model1	Model 2	Model 3	Model 4
TRANSPORT	0.143**	0.126*	0.132**	0.119**	-0.129*	-0.115	-0.083*	-0.066	-0.015	-0.012	-0.050	-0.053*
	0.067	0.067	0.054	0.049	0.077	0.078	0.048	0.043	0.030	0.033	0.030	0.030
SPACE_TECHNOLOGY_WEAPONS	0.232**	0.207**	0.208**	0.195**	-0.219**	-0.195**	-0.166**	-0.151**	-0.013	-0.012	-0.042	-0.045
	0.092	0.094	0.085	0.082	0.094	0.095	0.074	0.070	0.055	0.058	0.057	0.058
CONSUMER_GOODS_EQUIP	0.299***	0.282***	0.286***	0.270***	-0.229***	-0.213***	-0.188***	-0.169***	-0.070**	-0.069*	-0.098***	-0.101***
	0.069	0.070	0.060	0.054	0.079	0.080	0.055	0.048	0.035	0.038	0.035	0.035
CIVIL_ENG_BUILD_MINING	0.327***	0.313***	0.313***	0.293***	-0.245***	-0.230***	-0.205***	-0.180***	-0.082**	-0.082**	-0.108***	-0.113***
	0.071	0.072	0.061	0.054	0.080	0.081	0.056	0.048	0.037	0.039	0.036	0.036
EU	-0.029*	-0.030*	-0.037**	-0.040***	0.004	0.005	0.011	0.015	0.025**	0.025**	0.026**	0.025**
	0.017	0.017	0.016	0.015	0.017	0.017	0.015	0.015	0.011	0.012	0.011	0.011
JP	-0.046**	-0.052**	-0.062***	-0.057***	0.084***	0.070***	0.091***	0.084***	-0.038**	-0.018	-0.029*	-0.027
	0.019	0.021	0.022	0.021	0.019	0.019	0.020	0.019	0.015	0.017	0.017	0.017
IL	-0.161*	-0.159*	-0.163*	-0.165*	0.178**	0.173**	0.175**	0.177**	-0.017	-0.014	-0.011	-0.012
	0.089	0.090	0.090	0.090	0.076	0.077	0.076	0.075	0.073	0.073	0.074	0.074
N	8144	8144	8144	8144								
Log pseudo likelihood	99369.57	99137.4	98612.26	98449.24								
Pseudo R2	0.055	0.058	0.063	0.064								
Wald Chi2	644.40***	706.44***	812.06***	821.44***								
Generalized Hausman test of IIA – Chi2	78.98	80.58	88.32	120.81								

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.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$

Appendix

A. Sampling Strategy

To draw our sample, we collected all patent applications filed with the EPO with priority dates between 2003 and 2005 listing inventors living in the following countries at the time of the application: Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, UK, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Sweden, and Slovenia, Israel, the U.S., or Japan (sampling unit). This resulted in 301,503 unique EP patent applications and 797,515 inventor entries. Since most of the inventors are mentioned on more than one patent, the population of inventors contained fewer individuals.

To reach our goal of 21,000 answers, given experiences with response rates of earlier inventor surveys like the PatVal1 survey (Giuri et al. 2007) or the RIETI-Georgia Tech inventor survey (Nagaoka and Walsh 2009a), we had to send out approximately 105,000 questionnaires. Since we sampled the addressees of our survey from a list of non-unique inventor entries, we sampled more patents than actually needed (140,000 EP patent applications). The patents were sampled randomly. Then, the addressee of the survey was also chosen at random among the inventors listed on each patent document. Duplicate inventors or inventors with incomplete addresses were removed from the sample before sending out the invitation letters. Since the unit of analysis is the patent application, we are confident that this procedure does not lead to biased results. This process resulted in 124,134 unique EP patent application-inventor combinations. 50% of the inventors were from Europe and Israel²¹, 13% from Japan, and 37% from the U.S. Table A1 provides an overview over our sampling strategy.

²¹ We addressed the following numbers of inventors per country: BE: 1,531; DK: 1,107; DE: 23183; FI: 1,355; FR: 8,922; GB: 5,844; GR: 174; IE: 533; IL: 1,183; IT: 4,862; LU: 184; NL: 3,358; NO: 813; AT: 1,517; PL: 267; SE: 2,218; CH: 3,060; SI: 193; ES: 1,298; CZ: 245; HU: 301.

Table A1: Sampling strategy by country or region

	Sampled inventors (planned)	Addressed inventors	Expected number of responses	Expected response rate [%]	number of responses	response rate [%]	response rate corrected for quality-neutral losses* [%]
Germany		23,183	4,637	20	5,307	22.9	22.9
Denmark		1,107	221	20	195	17.5	17.9
Spain		1,298	260	20	272	21.0	22.3
France		8,922	1,784	20	1,890	21.2	21.9
Hungary		301	60	20	84	27.9	30.9
Italy		4,862	972	20	1,583	32.5	33.4
The Netherlands		3,358	672	20	607	18.0	18.5
UK		5,844	1,169	20	851	14.6	14.9
Austria		1,517	303	20	317	20.8	21.9
Belgium		1,531	306	20	343	22.4	22.9
Finland		1,355	271	20	219	16.2	17.9
Greece		174	35	20	44	25.3	26.8
Ireland		533	107	20	105	19.7	21.4
Luxembourg		184	37	20	45	24.5	33.6
Norway		813	163	20	120	14.8	16.2
Poland		267	53	20	77	28.8	30.6
Sweden		2,218	444	20	402	18.1	18.5
Switzerland		3,060	612	20	675	22.1	22.7
Slovenia		193	39	20	65	33.7	35.3
Czech Republic		245	49	20	86	35.1	38.4
Israel		1,183	237	20	189	15.9	16.7
EU+Israel	65,000						
Japan	25,000	16,125	4,838	30	4,972	30.8	31.3
U.S.	50,000	45,861	6,879	15	4,119	9.0	11.4
Total	140,000	124,134	24,146	100	22,567	18.2	20.0

♦ Quality-neutral losses include losses due to wrong addresses or the death of the inventors prior to receiving the questionnaires.

Table A2. Technology and country composition of the sample by firm size

	Large firm (≥250 empl.) (%)	Medium sized firm (100-249 empl.) (%)	Small firm (<100 empl.) (%)
Main technology class			
Electrical Engineering (23.91%)	86.45	3.48	10.06
Instruments (16.35%)	75.66	5.15	19.19
Chemicals and Pharmaceuticals (19.86%)	82.99	5.00	12.01
Process Engineering (13.45%)	74.44	7.58	17.98
Mechanical Engineering (18.98%)	82.79	4.60	12.61
Consumption and Construction (7.45%)	65.87	7.97	26.16
Region			
EU + Israel	75.81	6.10	18.09
Japan	94.93	1.99	3.08
U.S.	76.52	5.90	17.58
Total	80.16	5.15	14.69

Number of observations =22,567

Table A3. Valid, missing and “don’t know” responses on patent uses

Dependent variables	Yes	No	don't know	missing	Total
Blocking	9404	4881	812	3531	18628
Commercial use	7543	6124	1498	3463	18628
Licensing	857	11602	3094	3075	18628
Sale	693	12559	2173	3203	18628
Creation of new firm	519	14042	986	3081	18628
Used	6580	4710			11290

Dependent variables	Yes	No	don't know	missing	
Blocking	50.48%	26.20%	4.36%	18.96%	100%
Commercial use	40.49%	32.88%	8.04%	18.59%	100%
Licensing	4.60%	62.28%	16.61%	16.51%	100%
Sale	3.72%	67.42%	11.67%	17.19%	100%
Creation of new firm	2.79%	75.38%	5.29%	16.54%	100%

Table A4. Description of the dependent variable: motivations for patenting and patent uses

Variable	Description	Source
REASONS FOR PATENTING	Nine variables generated from the following survey question: “How important were the following reasons for patenting this invention at the time when the patent was filed? (<i>Please refer to the time of the application of the patent</i>)”. The importance of the following reasons was assessed on a 5-point Likert scale (1 not important, 5 = very important): commercial exploitation (obtain exclusive rights to exploit the invention economically), licensing, cross licensing, prevent imitation (protect present or future inventions by patenting the “finding around”), blocking patents (avoid that others patent similar inventions, complements or substitutes), reputation, prevention of infringement suits, pure defense, technical standard.	PatVal2
INTERNAL USE OF THE PATENT	A variable generated from the following question: “Have the applicant(s) or affiliated parties ever used this patented invention commercially, i.e., in a product, service or in a manufacturing process?”. The variable is equal to 1 if the applicant(s) or affiliated parties ever used this patented invention commercially, i.e., in a product, service or in a manufacturing process, 0 otherwise.	PatVal2
PATENT SALE	A variable generated from the following question: “Was the ownership right to the patent sold to another party not related to the original owner(s) or applicant(s)?”. The variable is equal to 1 if the ownership right to the patent was sold to another party not related to the original owner(s) or applicant(s), 0 otherwise.	PatVal2
LICENSE	A variable generated from the following question: “Has this patent been licensed by (<i>one of</i>) the patent-holder(s) to an independent party?”. The variable is equal to 1 if the patent has been licensed by (one of) the patent-holder(s) to an independent party, 0 otherwise.	PatVal2
STARTUP	A variable generated from the following question: “Has this patent been used by any of the inventors or applicants to found a new company?”. The variable is equal to 1 if the patent has been used by any of the inventors or applicants to found a new company, 0 otherwise.	PatVal2
USED	Variable equal to 1 if the patent has been used by any of the inventors or applicants in any of the four possible aforementioned ways: INTERNAL USE OF THE PATENT, PATENT SALE, LICENSING, STARTUP; 0 otherwise.	PatVal2
BLOCKING	Variable equal to 1 if BLOCK COMPETITORS was an important reason for patenting the invention (BLOCK COMPETITORS >3)	PatVal2
COMMERCIAL USE	Variable equal to 1 if USED=1 and (BLOCKING=0 or BLOCKING=1) 3=SLEEPING PATENT	PatVal2
STRATEGIC NON-USE	Variable equal to 1 if BLOCKING=1 and USED=0	PatVal2
SLEEPING PATENTS	Variable equal to 1 if BLOCKING=0 and USED=0	PatVal2

Table A5. Description of explanatory variables

Explanatory variables		
ONE_COMPETITOR	A dummy variable generated by the following question “During the invention process, were you aware of one or of several other parties competing with you for the patent? (Yes, one other party; Yes, several other parties; No other parties known, I don’t know)”. The variable is equal to 1 if the answer was “Yes, one other party”	PatVal2
SEVERAL_COMPETITOR	A dummy variable generated by the following question “During the invention process, were you aware of one or of several other parties competing with you for the patent? The variable is equal to 1 if the answer was “Yes, several other parties”	PatVal2
DUMMY_MISSING_COMPETITOR	Dummy variable equal to 1 if ONE_COMPETITOR or SEVERAL_COMPETITOR is missing	PatVal2
IPC4_NFIRMS1998	Number of patent applicants in the IPC 4-digit technological class in 1998	PATSTAT
XY_PATENT_REF	Number of overlapping claims with earlier patents, i.e. X or Y references assigned by patent examiners	PATSTAT
TOT_ECLA	Number of technological classes of the patent	PATSTAT
CLAIMS	Number of claims reported in the patent document	PATSTAT
GENERALITY	Generality index : $1 - \sum(n_i) s_{ij}$ where s_{ij} is the percentage of citations received by patent i that belong to patent class j , out of n_i patent classes, Hall et al (2001)	PATSTAT
DUMMY_MISSING_GENERALITY	Dummy variable equal to 1 if GENERALITY is missing	PATSTAT
FAMILY_SIZE	Size of the INPADOC patent family, i.e. the number of equivalents or patent applications directly or indirectly linked through a priority date	PATSTAT
OPPOSITION	Dummy equal to 1 if the patent has been opposed at the EPO.	PATSTAT
SIZE_ORGANIZATION	6 dummies indicating the number of employees of the organization in which the inventor was employed at the time of the invention: 1-99, 100-249, 250-499, 500-999, 1000-4999, 5000 and more employees.	PatVal2
PATENT_STOCK	Patent stock of the parent company at the year before the priority year of the patent, calculated with a declining balance formula with a 15% depreciation rate	PATSTAT, Amadeus, Compustat
NR_INVENTORS	Number of inventors listed in the patent	PATSTAT
MACRO_TECH_CLASS	6 macro technological classes based on the OST classification: Electrical Engineering, General Instruments, Chemistry, Process Engineering, Mechanical Engineering, Construction and consumer goods	PATSTAT
TECH_CLASS	30 technological classes based on the OST classification: See the annex for the list of technological classes	PATSTAT
COUNTRY	4 dummies indicating the country/region of the inventor of the patent: EU, IL, US, and JP.	PATSTAT
PRIORITY_YEAR	3 dummies indicating the priority year of the patent: 2003, 2004 and 2005.	PATSTAT
GRANTED	Dummy equal to 1 if the patent application has been granted as of 04/2011	PATSTAT