Research Policy 45 (2016) 1374–1385

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

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

Salvatore Torrisi[a,b,*], Alfonso Gambardella[b], Paola Giuri[a], Dietmar Harhoff[c,d], Karin Hoisl[c,e,f], Myriam Mariani[b]

[a] University of Bologna, Italy
[b] CRIOS—Bocconi University, Italy
[c] Max Planck Institute for Innovation and Competition, Germany
[d] Ludwig Maximilian University, Germany
[e] University of Mannheim, Germany
[f] Copenhagen Business School, Denmark

ARTICLE INFO

Article history:
Received 4 March 2014
Accepted 18 March 2016
Available online 5 April 2016

JEL classification:
L13
L20
O34

Keywords:
Intellectual property
Blocking patents
Sleeping patents
Strategic patenting

ABSTRACT

This paper employs data from a large-scale survey (InnoS&T) 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 regarding the reasons for patenting and the ways in which patents are being utilized. A substantial share of patents is neither used internally nor for market transactions, which confirms the importance of strategic patenting and inefficiency in the management of intellectual property. 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 some implications for innovation and patent policy.

1. Introduction

This paper focuses on comparisons between 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.

The explosion of patent applications at the European Patent Office (EPO) and the US Patent and Trademark Office (USPTO) raises concerns about the quality of applications and their effects on subsequent innovations and product market competition. Patent applications at the EPO grew from 197,539 in 2005 to 257,744 in 2012,[1] and USPTO applications rose from 390,733 in 2005 to 542,815 in 2012.[2] The growth in patent filings is at odds with survey responses from R&D managers who typically portray patents as a comparatively weak instrument for protecting innovation (Levin et al., 1987; Cohen et al., 2000; Arundel, 2001).

Further, a substantial number of patents are filed for purely strategic reasons (Hall and Ziedonis, 2001; Grindley and Teece, 1997) rather than for protecting significant inventions. Strategic patenting, 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). 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" (Schankerman, 2013: 479).

The evidence on how patents are actually used is limited. There are a few systematic studies showing that between 36% and 38% of

* Corresponding author.
E-mail address: torrisi@unibo.it (S. Torrisi).

[1] See http://www.epo.org/about-us/annual-reports-statistics/statistics/filings_de.html, accessed on 18.02.14.

[2] See http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm, accessed 18.02.14.

http://dx.doi.org/10.1016/j.respol.2016.03.021
0048-7333/

patents are never used (e.g., Giuri et al., 2007; Nagaoka and Walsh, 2009; Walsh et al., 2016). However, earlier surveys on inventions and patents typically focus on one or a few countries – e.g., Levin et al. (1987), Cohen et al. (2000), Harhoff et al. (2003), Nagaoka and Walsh (2009), 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.

Patents may remain unused for strategic reasons such as to prevent the entry of competitors (Gilbert and Newbery, 1982). Patents that serve the function of bargaining chips in cross-licensing negotiations or infringement suits may also remain unused until an agreement is reached. (Shapiro, 2001; Hall and Ziedonis 2001; Heller and Eisenberg, 1998).

This paper contributes to the literature on the economic utilization of property rights by analyzing different modes of patents uses. The first mode is *commercial use*, which includes patents used either internally in new products or processes or externally through licensing, sale and spinoffs. The second mode 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 occupied. Finally, the third mode is *sleeping patents* – patent applications filed for reasons different from commercial use and blocking other parties. We focus on three classes of correlates of patent uses: (i) the characteristics of the technological environment – technological complexity and competition; (ii) the patent value – measured by ex-ante observables like patent family size, number of claims, and oppositions; and (iii) legal validity – measured by overlapping references to prior art.

We use data on inventions as described in 8144 patent applications collected through the InnoS&T 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.

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 5 concludes.

2. Conceptual background and research questions

Besides the traditional role of patents as a mechanism that provides an exclusionary right to use inventions in the market (*commercial use*), the literature has examined various motives for patenting like prevent litigation, reduce the risk of holdup, and preempting competition.

Blocking patent applications filed to protect other inventions, 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. As mentioned before, we have focused on technological environment, the patent value and legal validity. 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.

2.1. 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 et al., 2001; Arora and Merges, 2004).

The exploitation of IPR assets may be hampered especially when too many property rights are granted to several parties (Heller and Eisenberg, 1998: 699). 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 licensing 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 work has studied the impact of technological characteristics on patenting (e.g., Hall and Ziedonis, 2001; von Graevenitz et al., 2013). Less known is the relationship between technological characteristics and patent use (e.g., Grindley and Teece, 1997). We address this question by asking what the differences between complex and discrete technologies in patent use are. 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.

2.2. Technological competition

Technological competition implies that a large number of firms patent in the same technological area. Technological complexity and competition are two distinct dimensions of the technological environment. von Graevenitz et al. (2013) 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 (e.g., Ziedonis, 2004; Noel and Schankerman, 2013). 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, which 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 (*strategic non-use*). On the other hand, Arora et al. (2001) argue that competition in the same technological area increases the likelihood of licensing (*commercial use*). Moreover, technological competition may spur firms to get patented inventions faster to the market. Because of these contrasting forces, the relationship between competition and patent use is difficult to predict.

2.3. 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).

We analyze if 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.

2.4. Legal validity

The legal validity of a patent can affect use. The number of X and Y references measure the degree of overlapping claims with earlier patents.[3] Overlapping claims measure the inventive step above a competitor's patents and thus a large number of overlapping claims indicate controversial patents, i.e., patents of uncertain validity. The presence of X and Y references signals that the use of a patent may be constrained by a high risk of legal disputes, which may affect the type of use.

3. Data and methodology

3.1. The InnoS&T survey

The InnoS&T survey 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. Bibliographical and procedural information on the patents in our sample was supplemented from the PATSTAT database as of 04/2011.

Our sampling unit (as well as unit of analysis) is the EP patent application. It is reasonable to assume that only patents with higher expected quality 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. This reduces the probability of a home country bias.

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 PatVal survey (Giuri et al., 2007). The interviews revealed that – in contrast to scientific publications – 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 described in the online Appendix resulted in 124,134 unique patent/inventor combinations.

We received 23,044 answers, which correspond to a response rate of 18% (after an adjustment for neutral losses, the response rate amounts to 20%). Table A1 in the online Appendix provides an overview of the response rates by country. After elimination of non-response on the type of the inventor's employer at the time of the invention the number of observations drop to 18,628 observations. The number of observations further drops to 11,850 mostly because of missing values and "do not know" responses (which we coded as missing) to the questions used for building the dependent variable (see Table A3 in the online Appendix).[4] In addition, missing values for explanatory variables are responsible for a small reduction in the sample size, from 11,850 to 10,650 observations. When rejected (or withdrawn) patent applications are excluded, the final sample drops to 8144.

We 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).[5] The Little's MCAR test cannot reject the assumption of randomness in missing values—Chi-square = 1.5150, p-value = 0.4688 (Chi-square = 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.

We include pending patent applications, since pending and granted patents show similar patterns of use 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). To account for differences between pending and granted patens, our estimates include a dummy variable for granted patents.[6]

A concern with our survey may be that inventors are not sufficiently informed about the motive for patenting. 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).

Finally, it is also worth noting that both our survey instrument and sampling frame are slightly different from those used by Walsh et al. (2016). Importantly, Walsh et al. draw their survey sample from triadic patents which is a sub-set of all EPO patents

3.2. Variables

3.2.1. Reasons for patenting

Table 1 describes the questions from which we generated the variables used in the analysis and Table 2 reports the descriptive statistics.

Table 3 illustrates the average importance of different reasons for patenting, on a Likert scale varying from 1 (not important) to 5 (very important), at the time of the patent application. Prevention of imitation and commercial exploitation (obtain exclusive rights

[3] 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 16.12.14).

[4] We excluded cases of pure cross-licensing, i.e. when the patent is used in cross-licensing but not used internally.

[5] See Table 1 for a description of *Blocking* as a reason for patenting. As discussed later, we combined *Blocking* and *Used* to obtained different categories of patent strategies.

[6] It is worth recalling that the European Patent Office suggests that applicants 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." cf. http://www.epo.org/learning-events/materials/inventors-handbook/protection/strategy.html).

Table 1
Description of variables.

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? *(Please refer to the time of the application of the patent)”*. 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.	InnoS&T
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.	InnoS&T
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.	InnoS&T
License	A variable generated from the following question: “Has this patent been licensed by *(one of)* 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.	InnoS&T
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.	InnoS&T
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.	InnoS&T
Blocking	Variable equal to 1 if BLOCK COMPETITORS was an important reason for patenting the invention (BLOCK COMPETITORS > 3)	InnoS&T
Commercial Use	Variable equal to 1 if USED = 1 and (BLOCKING = 0 or BLOCKING = 1) 3 = SLEEPING PATENT	InnoS&T
Strategic Non-Use	Variable equal to 1 if BLOCKING = 1 and USED = 0	InnoS&T
Sleeping Patents	Variable equal to 1 if BLOCKING = 0 and USED = 0	InnoS&T
Triples	This variable is based on the frequency with which three firms hold EP patents reported in the other two firms’ patents as X or Y references. It 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.	von Graevenitz et al. (2013)
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”	InnoS&T
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’	InnoS&T
Dummy_Missing_Competitor	Dummy variable equal to 1 if ONE_COMPETITOR or SEVERAL_COMPETITOR is missing	InnoS&T
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: $1-\sum_{j}^{}$(ni)sij where sij is the percentage of citations received by patent i that belong to patent class j, out of ni 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.	InnoS&T
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
N_INVENTORS	Number of inventors listed in the patent	PATSTAT
Technological Classes	30 technological classes based on the OST classification, developed by the Fraunhofer ISI, the Observatoire des Sciences et des Technologies and the French patent office (INPI) (http://www.wipo.int/ipstats/en/statistics/patents)	ISI-OST-INPI
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

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.

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 (which henceforth is defined to include Israel) and the U.S, with the only exception of reputation that is less important in Japan compared to the other countries. These differ-

Table 2
Descriptive statistics (N = 8144).

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
Triples	2.21	1.33	2.04	0	4.78
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
N_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
EL_Dev_Engin_Energy	0.07		0	0	1
Audio_Visual	0.02		0	0	1
Telecom	0.05		0	0	1
Information Tech	0.05		0	0	1
Semiconductors	0.02		0	0	1
Optics	0.02		0	0	1
Anal_Measur_Control_Tech	0.08		0	0	1
Medical_Tech	0.05		0	0	1
Nuclear_Eng	0.00		0	0	1
Org_Chemistry	0.04		0	0	1
Macromol_Chemistry_Polymers	0.03		0	0	1
pharma_Cosmetics	0.03		0	0	1
Biotechnology	0.01		0	0	1
Agriculture_Food_Chem	0.01		0	0	1
Chem_Petrol_Basic_Mat_Chemistry	0.02		0	0	1
Surface_Tech_Coating	0.02		0	0	1
Materials_Metallurgy	0.02		0	0	1
ChemicaL_Eng	0.03		0	0	1
Mat_Processing_Textiles_Paper	0.04		0	0	1
Handling_Printing	0.05		0	0	1
Agric_Food_Proc_Mach	0.01		0	0	1
Environm_Tech	0.01		0	0	1
Machine_Tools	0.03		0	0	1
Engines_Pumps_Turbines	0.04		0	0	1
Thermal_Proc_Appar	0.02		0	0	1
Mechanical _Elements	0.05		0	0	1
Transport	0.07		0	0	1
Space_Technology_Weapons	0.01		0	0	1
Consumer_Goods_Equip	0.04		0	0	1
Civil_Eng_Build_Mining	0.04		0	0	1

ences (based on a test comparing the means of the variables across countries) are statistically significant at the 1% or 5% level, with the exception of technical standards.[7]

[7] Mean differences are statistically significant also when we compare two groups of observations, i.e. US vs Japan, US vs Europe, Japan vs Europe, with some exceptions. For example, we do not find any statistically significant differences between Europe and Japan with respect to pure defense and prevention of imitation. Also the differences between small and medium sized firms are not significant with respect to some reasons for patenting—e.g., prevention of imitation and prevention of infringement suits.

Table 3
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 Pharmaceuticals	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 InnoS&T survey data. Number of observations varies between 30 and 8144 depending on the subsample.

We do not find large differences across technological areas.[8] 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 PatVal 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% or the 5% level.

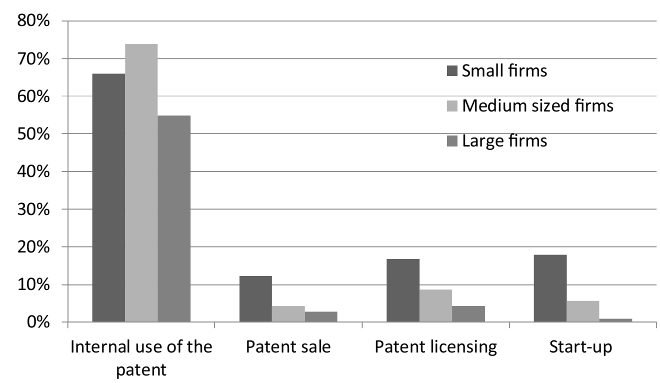

Fig. 1. Patent uses by firm size.

3.2.2. Uses of the patents

Table 4 reports the frequency of the following patent uses at the time of the survey: internal use in new products/services or manufacturing processes and external use (patent sale, patent licensing, cross-licensing, and creation of a new firm). It also shows the share of used patents, i.e. patents that were used for any of the aforementioned uses.[9]

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.[10]

Japan shows the largest share of unused patents (46%) compared to Europe (38%) and the U.S. (36%), which is probably due to the lower share of granted patents. Compared to Europe, the U.S. exhibits a larger share of patents licensed (10.5% in the U.S. vs. 6.4% in Europe vs. 3.5% in Japan) and sold (7.6% in the U.S. vs. 4.2% in Europe vs. 2.2% in Japan), confirming that markets for technology are more developed in the U.S. than in Europe and Japan (Arora and Gambardella, 2010). New venture creation based on patents also occurs more frequently in the U.S. (6.2%) than in Europe (4.5%) or Japan (0.8%).

We also find differences across technologies: 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. Whereas the share of used patents (all uses) is lowest in chemicals and pharmaceuticals compared to the other technologies, it is largest in process engineering (67%) and consumption and construction (76%).

Small and medium-sized firms (SMEs) are more active in internal use and licensing compared to large firms (see Fig. 1). Patent sale and new firm formation spawned by patents are also more frequently observed for SMEs 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 patents in their portfolio than SMEs. Larger firms typically have larger patent portfolios and the high proportion of unused patents points to strategic reasons (e.g., fencing) or other motives (e.g., inefficiency in the management of intellectual property). These differences (based on a

[8] The six technological classes reported in Tables 3–5 are obtained by aggregating the 30 OST technological classes described in Tables 1 and 2.

[9] Table 1 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 4 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.

[10] One may wonder about the association between non-use and renewal fees. 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 are 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 dropped applications that had been withdrawn or rejected, patents for which the applicant stops paying fees are not taken into account.

Table 4
Uses of patents: share of total patents.

	Internal use of the patent	Patentsale	Patent licensing	Start-up	Usedpatent
Total	0.576	0.043	0.064	0.040	0.606
EU + Israel	0.590	0.042	0.064	0.045	0.620
U.S.	0.591	0.076	0.105	0.062	0.640
Japan	0.530	0.022	0.035	0.008	0.541
multivariate test on means	***	***	***	***	***
Electrical engineering	0.567	0.039	0.068	0.035	0.596
Instruments	0.557	0.057	0.058	0.053	0.590
Chemicals and Pharmaceuticals	0.489	0.044	0.067	0.029	0.529
Process engineering	0.646	0.047	0.082	0.041	0.669
Mechanical engineering	0.571	0.031	0.040	0.027	0.591
Consumption and Construction	0.723	0.053	0.090	0.081	0.758
multivariate test on means	***	**	***	***	***
Small firms [<100 empl.]	0.660	0.122	0.167	0.179	0.765
Medium sized firm [100–249 empl.]	0.739	0.043	0.086	0.056	0.770
Large firm [> = 250 empl.]	0.548	0.027	0.042	0.010	0.562
multivariate test on means	***	***	***	***	***

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Authors' computations based on InnoS&T 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.

test comparing the means of the variables) are again statistically significant at the 1% and 5% level.[11]

3.2.3. *Dependent variable*

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, i.e. scores 4 (important) or 5 (very important) on a five-point Likert scale. Blocking is an important reason for patenting in 67% of cases.

Used is equal to 1 when the patent has been used either *internally* or *externally* (see Table 1 for a detailed description). As Table 2 shows, used patents account for about 61% of the sample. 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;

Strategic non-use—this mode of patent use involves blocking patent applications that remain unused;

Sleeping patents—which denote patents filed for reasons different from blocking other parties and which are not being used.

Filing a patent for commercial use often yields some blocking effect, as well. Moreover, blocking patents are not easily distinguishable from other reasons for patenting like the prevention of imitation (Cohen et al., 2002: 1358). For these reasons, the *commercial use* category includes also patent applications aiming at blocking other patents.

We excluded cases where blocking was an important reason for patenting and the patent was used in cross-licensing deals but not internally (17 out of 8114 observations). The assignment of the observations to the three groups is mutually exclusive and exhaustive. Table 5 describes the distribution of the three types of patent uses in our sample.[12]

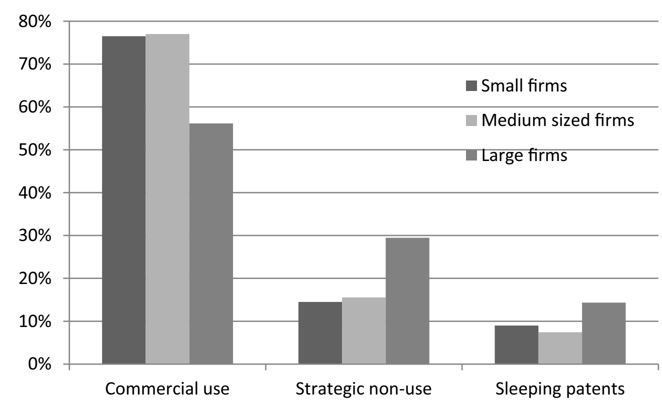

Fig. 2. Commercial use, strategic non-use and sleeping patents by firm size.

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

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 SMEs (see Fig. 2).

These differences (based on a test comparing the means of the variables) are statistically significant at the 1% level. Mean differences between EU and US and between small and medium firms are not statistically significant.

3.2.4. *Key regressors*

Our first covariate of interest is technological complexity. We counted the frequency with which three firms hold EP patents reported in the other two firms' patents as X or Y references (von Graevenitz et al., 2013). Our variable (TRIPLES) is equal to the average number of triples (cross X or Y references among three firms) over the period 1988–2002 and varies across the 30 OST technology areas. A larger average number of triples signals more complexity and transaction costs in the market for technology (Harhoff et al., 2016).

[11] Mean differences are statistically significant also when we compare two groups of observations.

[12] Our categories, although based on criteria that mix motives with actual use, nevertheless correspond reasonably well to the three categories proposed by Walsh et al. (2016) based on the actual use of patents. Thus, internal use is fairly similar to 'commercial' use in Walsh et al, strategic non-use patents is fairly similar to their definition of 'pre-emptive' patenting but sleeping patents do not map on well to their category of failed patents.

Table 5
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: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Authors' computations based on InnoS&T survey data. Number of observations varies between 444 and 8144 depending on the subsample.

We use 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).[13]

We also rely on information gathered through the InnoS&T survey to measure the extent of competition that the firm experienced during the research process leading to the patent. InnoS&T 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.

To measure patent value, we employ the size of the INPADOC patent family (FAMSIZE), i.e. the number of equivalents or patent applications directly or indirectly linked through a priority date.[14] The literature has found that the size of a patent family and forward citations are correlated with the economic (private) value of inventions (Harhoff et al., 1999, 2003; Hall et al., 2005). 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 noting that the 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.[15]

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. (2005), 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.

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.

We use a dummy variable that takes a value of 1 if an opposition had been filed against the patent at the EPO (OPPOSITION). Finally, TOT_ECLA refers to the number of ECLA (European Classification System) technology classes assigned to the patent.

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.

Correlations between variables are relatively low, indicating that collinearity of covariates should not be a concern.[16]

3.2.5. Controls

We use 30 OST technology areas of the patent described Tables 1 and 2. Pharmaceuticals and cosmetics are used as reference category in the regressions. 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. The InnoS&T 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) and 16% 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).[17] Finally, we control for the priority years (2003–2005) of the patents and the geographical area of residence of the inventors: Europe, Japan and the U.S.

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

[14] 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 16.12.14).

[15] 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.

[16] Pairwise correlations are reported in the online Appendix, Table A4.

[17] $KPAT_t = PAT_t + (1-\delta)KPAT_{t-1}$, where PAT_t are the annual patent counts, PAT_t is the patent stock and δ is the depreciation rate (see Hall et al., 2005).

3.3. Method

We use sampling weights 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 non-response 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:

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

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.

The generalized Hausman test for independence from irrelevant alternatives (IIA) failed to reject the IIA assumption in all model specifications (see Table 6).

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. Model 2 adds technological complexity and technological competition while Model 3 adds measures of patent value.[18] 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.

4.1. Technological characteristics and competition

We start by examining the association between complexity and patent uses. In model 2 of Table 6, we analyze complexity via the average number of triples (TRIPLES). 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.

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. These nuanced findings suggest 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, e.g., to preempt substitute innovations.

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. Whereas SEVERAL_COMPETITORS measures competition for a specific patent, a large number of patent holders (IPC4_NFIRMS) proxies for a broader dimension of the technological environment, such as IPR fragmentation and high transaction costs in the market for technology.

4.2. Patent value and legal validity

FAMILY_SIZE is negatively related 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*. This result indicates the more valuable projects attract more R&D effort.

Our results show that the effect of OPPOSITION on patent use is not significant in our empirical setting. This non-result probably depends on the ambiguity of this variable, as a signal of complexity and problematic enforceability, on one side, and value, on the other (Hall et al., 2009).

Our measures of patent value overall indicate that higher value patents are more likely to be used commercially and less likely to remain unused.

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).

The control variables exhibit the expected effects.

4.3. Robustness checks

To further check for any effect of missing observations in our estimations, we created a new version of *Commercial use*. We coded as missing only the observations for which the answers about all

[18] We also estimated a model with TRIPLES and controls, without technological competition. The results available from the authors are very similar to model 2.

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
Triples		−0.016	−0.015	−0.014		0.018	0.018**	0.017		−0.002	−0.003	−0.003
		0.020	0.020	0.020		0.019	0.019	0.019		0.013	0.013	0.013
One_Competitors		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	0.008		0.027*	0.028**	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	0.004		0.001	0.001	0.001
		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	0.009			−0.031***	−0.028***
			0.016	0.012			0.019	0.013			0.006	0.006
N_INVENTORS			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			0.073*	0.070*			−0.011	−0.008			−0.061*	−0.062**
			0.042	0.042			0.036	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**	−0.082***	−0.082***	0.094***	0.092***	0.097***	0.097***	−0.014	−0.014	−0.015	−0.015
	0.031	0.031	0.031	0.031	0.029	0.028	0.028	0.028	0.025	0.025	0.025	0.025
1000–4999 Employees	−0.080***	−0.078***	−0.081***	−0.081***	0.039*	0.039	0.043*	0.042*	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
>5000 Employees	−0.119***	−0.118***	−0.120***	−0.118***	0.067***	0.066***	0.067***	0.065***	0.052***	0.052***	0.053***	0.053***
	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**	−0.027**	−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
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*	−0.164*	−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	99132.07	98606.33	98444.03								
Pseudo R2	0.055	0.058	0.063	0.064								
Wald Chi2	644.40***	708.41***	814.67***	823.80***								
Generalized Hausman test of IIA, Chi2 (p-value)	78.98 (0.693)	97.03 (0.395)	120.44 (0.195)	121.52 (0.213)								

Notes: Robust standard errors are adjusted for clusters by firms' identifiers. All models include dummies for missing values for generality, missing values for competition, priority year of the patent and 30 OST technological classes. The baseline category for the OST technological class dummies is Pharmaceutical and Cosmetics.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

four patent uses were missing or "don't know". 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) were coded as "no". We followed the same procedure with the questions on motivations for patenting, including blocking patents. This led to a sample of 10,319 observations. We ran the multinomial logit regressions with the new version of the dependent variables. The estimates yield very similar results; they are available upon request from the authors.

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, we ran separate estimations for the sample of Europe, U.S. and Japan. Results are confirmed in all estimations, although the significance level of a few marginal effects diminishes because of the smaller number of observations in the separate samples. We also estimated the regressions including dummies for 15 European countries and for two groups of European countries with smaller number of observations (EAST-EU and SOUTH-EU), without substantial changes in the results.

Finally, we estimated the 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

In sum, a substantial share of patents remained unused (~40%) and about 67% of patent applications were filed to block other patents. We find important cross-technology and cross-country differences. Japan and EU exhibit a larger share of unused patents than the US, which is characterized by a larger share of patents 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.

We find a positive association between commercial use and the presence of another party competing with the firm for the patent. However, a large number of competitors for the patent also increases the likelihood of 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 strategic patenting. Moreover, strategic non-use is more likely when the patent has limited or uncertain legal validity and the applicant holds a large patent portfolio.

Patents that remain unused for strategic reasons (about 26% of our sample) produce private benefit to the patent holder. However, they may conceivably be associated with anticompetitive behavior or waste of resources from a societal viewpoint and so have received a lot of attention from scholars and policy makers. Patent policies that limit the scope and enforceability of patents have been proposed to reduce IP fragmentation and blocking patents but our results suggest they would also affect other kinds of patents, including unused patents that are not necessarily filed for strategic, anticompetitive reasons. Moreover, as we noted in Section 2, Japan, which operates a narrow scope patent policy nevertheless has a larger percentage of strategic non-use patents. Legal scholars argue that in some cases a limitation to the right of not use in patents would lower the risk posed by patent trolls (e.g., Penalver and Liivak, 2013). Our analysis does not allow us to come to a conclusive decision in favor or against such a provision, given that the benefits and costs are difficult to assess. However, our results highlight that there might be substantial benefits that patent owners draw from being able to keep patent rights unused. These would have to be balanced against possible harm imposed on other economic agents.

Additionally, a more stringent inventive step criterion in patent examination and post-grant reviews would likely increase the quality of patent applications and discourage patent filings that aim mostly at creating strategic defenses and barriers to entry. A significant share of patents is "sleeping" (about 13%), i.e., they are unused for other reasons than blocking. Patent policies that increase the steepness of renewal schedules lead to more valuable patent applications (Cornelli and Schankerman, 1999; De Rassenfosse and Jaffe, 2014) and should reduce the rate of sleeping patents.

Measures 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, can stimulate more intense exploitation of sleeping patents. In Germany license of right is declared for about 6% of all granted applications (Rudyk 2012).

Sleeping patents are more likely in large firms (more than 1000 employees), which suggests that there is room for policies that foster the transfer of sleeping patents owned by large firms to smaller firms and startups. These policies could be favored by the diffusion of patent exchange platforms (e.g., IP Marketplace in Denmark and the Innovation Market in Germany) and patent aggregators (e.g., patent funds).

Patents that protect general-purpose technologies are more likely to remain sleeping probably because of high adaptation costs. Public policies that reduce the cost of adoption of general-purpose technologies thus could affect sleeping patents like, for example, policies supporting the setup of crowdsourcing platforms for the generation of ideas about the application of existing general-purpose inventions.

Acknowledgements

We thank Sadao Nagaoka, Hitotsubashi University and RIETI, for collaborating on the survey of Japanese inventors.

We also thank the participants to the Conference on Patent Use, London and the 15th DRUID Conference in Rome for helpful comments. Suma Athreye, Ashish Arora and two anonymous referees also provided valuable suggestions. The data collection was supported by the InnoS&T EU FP7 collaborative project under grant agreement No. 217299. Dietmar Harhoff acknowledges support by the DFG's collaborative research program SFB/TR 15 (project C2). Karin Hoisl acknowledges financial support from the Sauer Stiftung. Alfonso Gambardella, Paola Giuri, Myriam Mariani and Salvatore Torrisi acknowledge the financial support by the Italian Ministry of Education, University and Research (MIUR), project # B41J12000160008.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.respol.2016.03.021.

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