Quality versus quantity: Strategic interactions and the patent inflation[1]

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ABSTRACT

This paper investigates the impact of companies' motivations to patent on the characteristics of their patent portfolio using international survey data. Three main findings emerge. First, companies mainly file for an exclusion motive and to protect their freedom to operate (FTO). Second, the exclusion motivation is driven by competitors' patenting behavior and pushes companies to apply for patents, suggesting a "patent arms race." Third, there is strong evidence that, in managing their patent portfolio, firms face a trade-off between quality and quantity, as measured with the average degree of internationalization of patents. This trade-off is exacerbated by the FTO motivation.

JEL Classification: O31, 032, 034, L25

Keywords: freedom to operate, licensing, motivation to patent, patent family, patent portfolio, patent strategy.

[1] The authors are particularly grateful to Silvia Appelt, Knut Blind, Peter Hingley, Karin Hoisl, Thomas Rønde and Bruno van Pottelsberghe for useful comments. The article was written when Gaétan de Rassenfosse was visiting at INSEAD. Gaétan de Rassenfosse gratefully acknowledges financial support from the Belgian National Science Foundation (FNRS). This study does not necessarily reflect the view of the OECD or its member countries.

1. INTRODUCTION

Scholars in the field of the economics of innovation and intellectual property are in an uncomfortable position. Whilst patent data has become a central piece of many economic reports and studies on innovativeness, it is increasingly acknowledged that a large share of patent applications are driven by strategic considerations, hence undermining the usefulness of patent-based indicators. Patent offices qaround the world have seen a constant increase in the number of patent applications over the past 20 years, the so-called "patent inflation." Several factors explain the boom in filings, from the emergence of new innovative economies to the appearance of new technologies and the arrival of new types of applicants (among which are small firms and universities) in the patent arena. The most important one, however, is probably related to what is commonly called "strategic patenting." Companies are reported to use patents in non-traditional ways, ranging from the setting up of patent fences, to patent submarines, defensive publications, or earning licensing revenues.

This paper precisely investigates the importance of various motives to patent and their effect on companies' patent portfolios. The data are collected from a large-scale international survey performed by the European Patent Office (EPO) in 2006. The objective of this paper it to assess the impact of the various motives on the size of the patent portfolio (the propensity to patent) and on its quality, as proxied by the average patent family size (i.e. the number of countries in which each patent is applied for).

The empirical results suggest that a trade-off exists between the quantity and quality of patent applications. The exclusion role of patents is the main motivation to use the patent system. Irrespective of the country, the industry, or the characteristics of the company, a majority of applicants patent for the exclusion motive, which is the most traditional of all motives and the main raison d'être of the patent system. Another strong motivation is defensive patenting. A total of 50% of companies patent in order to preserve their freedom to operate. Aggressive patenting behavior by competitors pushes companies to adopt a similar attitude. This finding suggests that some applicants engage in a patent arms race, which has led to the patent bubble. We also find evidence that this spiral effect is detrimental to the quality of patents. Two illustrations of the trade-off between quality and quantity are presented. First, companies that file patent applications to preserve their freedom of operation have a larger portfolio but of lower average value. Second, the quality of the patent portfolio decreases with the propensity to patent.

The structure of the paper is as follows. The next section reviews the literature on the motivations to patent. The hypotheses are formulated in Section 3. Section 4 presents the data and section 5 is devoted to the empirical investigation. The last section concludes and puts forward policy implications.

2. LITERATURE REVIEW

Two classical surveys have pioneered the literature on the measurement of strategic patenting. The first one is the Yale Survey performed by Levin, Klevorick, Nelson, Winter, and Gilbert (1987), which provides evidence that firms do not rely mainly on patents to appropriate the returns from their innovations. They rather rely on other mechanisms such as secrecy, lead time, or the use of complementary assets (the survey did not, however, rule out the fact that the effectiveness of these means is reinforced by the use of patents). The second major contribution, known as the Carnegie Mellon Survey, is owed to Cohen, Nelson, and Walsh (2000). The authors note that patents are used in non-traditional ways such as to prevent rivals from patenting related inventions, to use in negotiation, and to prevent suits. They further confirm that firms prefer secrecy and lead time advantage over patents to protect profits due to inventions, and that the “secrecy” strategy has intensified over time.

These findings led to the emergence of the so-called “patent paradox” popularized by Hall and Ziedonis (2001). The poor effectiveness of patents as a tool to protect profits due to their innovative efforts and the rise in the reliance on secrecy is apparently inconsistent with the strong increase in patent filings. There is now growing evidence that patents are used in various ways, such as to generate licensing revenues, to prevent suits, to block competitors, to maintain one's own freedom to operate, to enhance reputation, or as bargaining chips in negotiation. These uses are referred to as "strategic" and help explain why companies keep patenting despite their own apparent skepticism on the effectiveness of patent systems. Yet, the emergence of strategic patenting alone is not sufficient to reconcile the facts. Patent filings also increased due to the entry of countries such as China, Brazil, and India into the world patent system and to new actors, in particular SMEs and universities. New fields of research, such as nanotechnologies and biotechnologies, also contributed to the rise in patent filings (Guellec and van Pottelsberghe, 2007). Finally, changes in IP policies are found to account for part of the increase as well (de Rassenfosse and van Pottelsberghe, 2008; Sanyal and Jaffe, 2006).

A recent and comprehensive survey on the motivations to patent is performed by Blind, Edler, Frietsch, and Schmoch (2006). They analyze a broad set of motives for the patenting activity of German companies and suggest that the various reasons for patenting can be grouped into the following clusters of motives: i) *protecting motives*: protection from imitation and safeguarding of markets; ii) *blocking motives*, offensively or defensively; iii) *reputation motives*; iv) *exchange motives*: improved access to the capital market, exchange potential, and licensing income; and v) *incentive motives*: motivation of staff and internal performance indicators. An additional insight into the patenting motivations is provided by the PatVal project, which measured the motivations of licensing, cross-licensing, and blocking (Giuri et al., 2007). The licensing motive is particularly important for small companies, while patent blocking is mostly favored by large companies. Table 1 provides a detailed chronological survey of the literature on motivations to patent.

A more recent stream of the literature on patenting aims at analyzing the factors that drive the patenting behavior of applicants. For instance, Peeters and van Pottelsberghe (2006) find that the innovation strategy (e.g. the extent of research collaboration, or the orientation towards product innovation as opposed to process innovation) actually influences the size of the patent portfolio. They also find that the perception of the effectiveness of patent systems does not influence the propensity to patent. Using a sample of French manufacturing firms, Duguet and Kabla (1998) support the argument that the number of patents is influenced by strategic motivations: the willingness of firms to avoid trials and to reach a stronger position in technology negotiations both lead to higher patent counts. A recent contribution on the influence of patenting strategies on the characteristics of firms' patent portfolios is performed by Blind, Cremers, and Mueller (2009). They show that firms that use patents in order to protect their inventions receive on average more forward citations on their patents. Conversely, companies that use patents as bartering chips in collaboration receive much fewer citations.

There is therefore some evidence that firms' patenting motivations influence the characteristics of the patent portfolio. Yet, the evidence is scattered and often dedicated to a very specific research question or country, so that the impact of the motivations on the size and quality of a patent portfolio remains largely overlooked. It is the very purpose of this paper to contribute to this literature, with an international dataset and a comprehensive mapping of motivations.

In so doing, the paper also contributes to the understanding of two reasons for patenting on which little is known so far: the monetary and the defensive motives. In a recent paper, Zuniga and Guellec (2009) provide interesting insights into the monetary role of patents. They find that earning revenues are the first motivation to license to third parties, both for large and small companies. The use of patents for raising funds is very important for one-third of young European firms. Defensive patenting is analyzed by two recent contributions. Henkel and Pangerl (2008) interviewed German industrial firms and find that defensive publishing is highly popular, with two-thirds of the firms in their sample publishing defensively with a broad range of tools, including the patent system itself. Guellec, Martinez, and Zuniga (2008) present quantitative evidence on the defensive role of patents. In particular, they show that EPO applications that have never been cited as making a relevant contribution to the prior art are also those that provoke the most refusals or withdrawals. In other words, some companies file patent applications mainly to disclose information and generate prior art, which is akin to defending their own freedom to operate. It seems that defensive patenting is explicitly related to low-quality patents:

defensive patents that are later withdrawn are the most lethal, although they contribute to prior art to a lesser extent than granted patents.

Table 1 goes about here

3. HYPOTHESES

The paper aims at understanding the impact of companies' patenting strategies on the size and quality of their patent portfolio. In particular, the following hypotheses will be tested.

H1. The reliance on patents to exclude competitors has a positive impact on both the size and the quality of the patent portfolio.

The expected impact on the size of the portfolio derives directly from Arundel and Kabla (1998) who notice that the propensity to patent is higher among firms that find patents to be an important method for preventing competitors from copying. Regarding the impact on the quality of patent applications, Blind, Cremers, and Mueller (2009) observe that companies that use patents in the traditional way receive a higher number of citations, a metrics that is often associated with patent quality.

H2. Defensive patenting increases the propensity to patent but decreases patent quality.

Guellec, Martinez, and Zuniga (2008) make a clear link between defensive patenting and low quality patents. Two possible explanations can be put forward. First, applicants that patent defensively may be willing to establish prior art and do not necessarily intend to have their patents granted. Consequently, they put the minimum effort in drafting the application, which result in patent applications of lower quality. Second, defensive patenting could also be associated with patent flooding, a technique that consists in filing numerous low quality patent applications in order to build patent thickets. The latter practice is necessarily associated with a high propensity to patent.

H3. Monetary motivations have a negative impact on the quantity of patents applied for but a positive impact on their quality.

Recent evidence by Zuniga and Guellec (2009) as well as Graham, Merges, Samuelson, and Sichelman (2009) suggest that monetary motivations are particularly important among small firms. SMEs often base their business transactions on a small number of patents of particular relevance. They may face strong financial constraints and be very selective in deciding which inventions to patent given the high costs associated with the process. Hence we expect that monetary motivations result in a smaller portfolio of higher quality.

Beside the various impacts of the motivations, we suspect more generally that a trade-off exists between the quantity and the quality of patent applications. Any IP strategy must be decided alongside two dimensions: the number of inventions to protect (i.e. the number of priority filings (PF) to apply for) and the number of countries targeted for international expansion (i.e. the number of second filings (SF)). For any given IP-budget, companies with a low SF/PF ratio have clearly chosen a mass patenting strategy, whereas companies with a high ratio are more oriented towards quality. We hypothesize that such a trade-off exists.

H4. There exists a trade-off between the quantity and the quality of patent applications.

Note that studies performed at the individual level find that some inventors produce high quality inventions and are very productive at the same time (see for instance Ernst, Leptien, and Vitt, 2000). Similarly, other inventors produce low quality with a low productivity. It is important to keep in mind that our analysis is performed at the company level and, therefore, departs from that literature.

4. THE DATA

The data come from the Applicant Panel Survey carried out from June to September 2006 by the European Patent Office. The main purpose of the survey is to provide information on filing intentions for the EPO's forecasting exercise for budgetary planning purposes. A specific part of the survey was dedicated to the motivations to use the patent system. The next paragraph summarizes the methodology adopted by the EPO for the sampling methodology.[1]

A sample of 2,098 applicants was selected partly among the largest applicants and partly at random, covering overall about 31% of the total applications at the EPO. Contact details were successfully established for 1,524 applicants and 772 responses were returned (leading to a response rate of 51% of the contacted applicants, or 37% of the initial sample). The survey was carried out via telephone and mail interviews in German, French, Japanese, and English with the pre-established contact persons. Respondents were asked to rate a series of assertions between 1 (totally disagree) and 6 (fully agree). The answers to the questions related to the motivations to patent are summarized in Table 2.

Table 2 goes about here

Patenting in order to prevent imitation by competitors (Imitation), the most traditional reason for patenting, is the one that scores the highest, with a mean score of 4.60 and two-thirds of the applicants strongly agreeing. The statement related to the freedom to operate (Freedom) scores very highly as well. This motive is typically assimilated to a defensive strategy, in which firms patent "to prevent their own technological room to manoeuvre being reduced by the patents of others" (Blind, Edler, Frietsch, and Schmoch, 2006). It has a mean score of 4.22 and 50% of the applicants patent mainly to preserve their freedom of operation. The data thus suggest that patents are frequently used as a defensive mechanism: defensive publishing is not only common practice outside the patent system

(Henkel and Pangerl, 2008), but also at its very heart. Monetary motivations, captured by the Investors and the Licensing variables, matter for one-quarter to one-fifth of applicants.

Appendix Table 9 presents a breakdown by industry of the motivations to patent. The industry taxonomy used by the EPO is organized around 14 "joint clusters," described in Appendix 8.1. The Imitation motive is consistently among the most important for all fields. The Investors motivation is particularly high in biotechnology whereas the Licensing motivation has the highest score in the biotechnology, the computer, and the telecommunication industries. Interestingly, the telecommunication industry also scores the highest with the freedom to operate motive.

Various characteristics of applicants and their patents were collected in the survey. The variables used throughout the analysis are summarized in Table 3. Note that two samples are used for the estimates, due to data availability. "Patents in 2005" is the worldwide number of priority filings in 2005, as reported by the company. "FTE Researchers" is the total number of full-time researchers in 2005. "Persons Employed" is an ordinal variable ranging from one to nine, corresponding to nine size classes from 1 to 50,000+ employees.[2] "Time Lag" is defined as the average time between initial expenditure on R&D that might lead to patent applications and the first patent filing, measured in months. "Group" is a dummy variable taking the value 1 if the respondent belongs to a group. The variable "R&D Intensity" is defined as the number of FTE researchers divided by the total number of employees.[3] "Quantity" is the ratio between the variable "Patents in 2005" and "FTE Researchers"; it is a raw measure of a company's propensity to patent. Finally, the variable "Quality" is computed as the ratio between the total number of second filings over the years 2005 and 2006 and the total number of priority filings in 2005 and 2006 (i.e. an approximate measure of the family size).[4] A high ratio means that a company protects its inventions in many foreign markets, which is usually interpreted as the patent having a high value – as the cost of protection increases with the number of countries (OECD, 2009).

Table 3 goes about here

The mean time lag is 10 months, suggesting that R&D projects lead to a first patent application within the year. Each researcher produced on average 0.85 patents in 2005 (variable Quantity) and a representative patent is extended in one or two foreign markets on average as indicated by the variable Quality. Applicants from JP, US, GB, DE, and FR represent 70% of the total, the rest being split mostly between European countries. We used two samples for the analyses; they are driven by data availability. Although the two samples are of almost equal size (330 and 328), the overlap is only of 290 observations. Two samples are thus used to maximize the number of data points available. The columns labeled NRA report the p-values for tests of difference in means between samples. A high p-value indicates a rejection of the null hypothesis of a difference in means between the full sample and the corresponding restricted sample. The null is rejected for all the variables at the 10% probability threshold, except for the size variables in Sample 1 and the number of patent filings in Sample 2. It suggests that a few large applicants did skip some parts of the questionnaire. A more in-depth analysis of missing items is reported in Appendix 8.3.

Appendix Table 10 reports the mean values of the variables Time Lag, R&D Intensity, Quantity, and Quality broken down by industry. The biotechnology industry has the longest time lags as well as the highest R&D intensity. A typical invention in the telecommunication industry is protected in five countries, against three to four in the pharmaceutical industry. Interestingly, a greater number of patents are systematically associated with a lower quality, as witnessed by the negative correlation between these two variables (see column (5) in Table 10). Companies that file many patent applications per researcher will also extend the patent protection in a smaller number of markets. It is a first hint of the trade-off that applicants face between quality and quantity.

Two concerns regarding the validity of the data gathered can be raised. Firstly, one can wonder whether applicants answered reliably. The survey was carried out on behalf of the EPO and respondents may have answered strategically to appear in a more favorable light. There are a number of reasons to think that applicants showed their true colors, however. First, the response rate is in the range expected for such surveys. It is neither the sign of extremely high motivation nor of reluctance to participate in the survey. Second, the results presented in the empirical analysis (see in particular Table 5) are somewhat in line with our expectations, indicating that applicants have been broadly honest in answering. Finally, the non-response analysis shows that some applicants did skip part of the questionnaire, but these missing values have only a limited impact. The second concern is related to how general the present findings are. EPO patents are expensive and have a reputation for high quality. The underlying motivations might thus be different in a jurisdiction that would be perceived as more lax.

5. EMPIRICAL INVESTIGATION

The empirical analysis aims at understanding the impact of the motivations to patent on the size and the quality of a patent portfolio. We use the score on motivations to explain both the propensity to patent and the size of the patent family, or, respectively, quantity and quality metrics. A preliminary analysis is performed to unveil the factors that explain the observed heterogeneity in motivations to patent.

5.1 Preliminary analysis: Motivations to patent and profile of applicants

The correlation matrix reported in Table 4 provides a first insight into how the motivations relate to each other. Given that the variables are ordinal, the differences between neighboring levels are presumably not equidistant. We assume that the variables are generated by an underlying continuous normal distribution and we therefore estimate polychoric correlation coefficients. We also computed Spearman’s rank correlation coefficients and achieved very similar results.

Table 4 goes about here

The motives Imitation, Competition, and Hampering are strongly correlated with each other, and the Investors motivation is highly correlated with the Licensing one. It might therefore be appropriate to consider a broad *exclusion motive*, which would encompass the offensive role of protecting a market against competitive pressure, and a broad *monetary motive*, which aims at generating direct financial resources either by increasing the company's ability to raise capital or by earning licensing revenues. The two types of motives are uncorrelated (Investors) or even negatively correlated (Licensing), suggesting that these are two distinct strategies, implemented by different populations of firms.[5] The motivation Freedom is correlated with the other motives to a lesser extent and could constitute a group by itself, the *defensive motive*. This grouping is formally confirmed by a factor analysis and echoes Blind et al.'s (2006) results. Details of the factor analysis are provided in Appendix 8.4.

A multivariate analysis can be used to test whether the heterogeneity in the various answers of Table 2 depends on the characteristics of the applicants. Table 5 presents the results of ordered probit analyses. The score for each statement is taken as the exogenous variable and is regressed on a set of firm characteristics variables.

Table 5 goes about here

Four observations can be drawn from the estimates presented in Table 5. First, the more a company feels that its competitors use their patents to hamper its own access to technology, the more it will file patent applications with the same purpose. The variable "My competitors hamper" is a Likert-scale variable reciprocal to the own motivation of hampering others.[6] The score of the variable is positively associated with the score for the exclusion motives in columns (1) to (3). Whether the correlation is causal or driven by some unobserved market factor is of little relevance here and both effects are probably at play. Market characteristics such as the degree of competition call for an offensive patenting strategy, exacerbated by competitors' behavior. There seems to be some fertile ground for a "patent arms race," in which companies file patent applications in reaction to their competitors' own patenting behavior. The goodness-of-fit measures are much higher in column (3) than in the others.

This is due to the strong correlation between the “Hampering” motive and the variable “My competitors hamper.” It is, indeed, a good predictor of the company’s attitude in this respect.

Second, the significance of the variable time lag in column (2) is more evidence of the patent race. Companies that file more patents when competition is more intense will also be faster at filing them. The two variables clearly reflect that a firm’s motivation to patent and its competitive environment are intertwined with each other.

Third, the motivation to rely on the patent system to keep its own freedom to operate does not seem to be much affected by firms’ characteristics. Applicants roughly agree or disagree to a similar extent, independently of their characteristics. The main factor that plays a role is related to the geographical origin of the firm: Japanese and French firms seem to be particularly keen to protect their freedom to operate. Pitkethly (2001) already observed the importance of the freedom to operate motive for Japanese companies in a survey of UK and Japanese IP managers. Japanese companies also have a higher tendency to patent offensively, as shown in columns (1) to (3). Cohen, Goto, Nagata, Nelson, and Walsh (2002), who report that strategic motivations such as patenting in order to block competitors are much more prevalent in Japan than in the US, made a similar observation.

Fourth, monetary motives in columns (5) and (6) are clearly related to the applicant’s size: small companies are more likely to be motivated by the possibility of convincing investors or by the opportunity to license out their inventions. Large firms, which have easier access to bank loans and more equity, do not patent to raise capital, as opposed to small companies that compete more frequently for venture capital. Licensing is also known to be more important for small firms, which do not have the same diversification in manufacturing as large firms do. Small specialized R&D-intensive companies cannot implement all the inventions they produce and will, therefore, seek to license out. The empirical literature often finds that the probability to license is U-shaped, with small and large firms being more likely to license their patented inventions relative to medium-sized firms (Motohashi, 2008; Zuniga and Guellec, 2009). We do not observe a peak for the largest firms with our dataset. The monetary motives are particularly important for companies in audio, video and media, biotechnology, computers, organic chemistry, and telecommunication.

Overall, the explanatory power of the regressors is quite weak, as witnessed by the low R^2. It suggests that there are no strong predictors of any of the considered motivations. We performed ordered logit regressions and gained very similar results, in terms of both the sign and the significance of the estimated parameters. We also performed the regressions by controlling for the restrictive joint cluster as opposed to the non-restrictive joint clusters (see Appendix 8.1), and similar results were obtained.[7]

5.2 Impact of motivations on quantity and quality

The objective of this paper is to test whether the various motivations to use the patent system influence the observed propensity to patent (the *quantity*) and the size of the patent family (the *quality*). In order to assess the impact of each motive on the propensity to patent, we estimate a traditional patent production function (Hausman, Hall, and Griliches, 1984). The conditional expected number of priority patent applications filed by company *i* is given by an exponential mean parameterization function of the form:

$$E[p_i \mid X_i] = \mu_i = \exp(X_i'\beta + \varepsilon_i), \qquad (1)$$

where X is the vector of covariates (most importantly the number of FTE researchers and the groups of motives), β is the vector of parameters, and ε_i is the error term. The parameters of equation (1) will be estimated with a Poisson quasimaximum likelihood regression. This estimation method is particularly suitable since the number of patents is a count variable and the variable realistically follows a Poisson distribution: a few large patent portfolios and a lot of smaller portfolios, as illustrated in Figure 1. In addition, the Poisson distribution is of the linear exponential family, which ensures efficient estimates if the model is mis-specified (Gourieroux, Monfort, and Trognon, 1984). It is crucial to mention that the quantity of patents is measured by the number of priority filings and not by the total size of the patent portfolio, the reason being that we want to differentiate between the propensity to patent on the one hand and the size of the patent family (to capture the average quality of patents) on the other hand.

Figure 1 goes about here

The main determinant of the number of patents is the number of FTE researchers, as a measure of the resources devoted to innovation by the company. In addition to the role of researchers, equation (1) aims at testing whether the various motivations actually affect the number of patents applied by firms. Since some of the six motives are highly correlated with each other (see Table 4), a principal component analysis was performed to extract the most meaningful information. The first three factorial axes alone explain more than 70% of the variance. The first factorial axis captures the role of traditional motives, which consists of filing patent applications in order to protect from imitation and competitive pressure (variable Exclusion in Table 6). The second factor is mainly related to the monetary use of patents: either as a way to license out technology or to attract investors (Monetary). Finally, patenting in order to keep one's own freedom to operate is a third distinct motivation (Freedom). The coordinates of the firms on each of these three factorial axes are used as explanatory variables in equation (1). Details of the factor analysis are presented in Appendix 8.4.

The R&D–patent relationship is characterized by two components: a *productivity* effect and a *propensity* effect. More productive research efforts will lead to a greater number of inventions per unit of research input (productivity), and the propensity to patent will determine how many patents will be applied for a given number of patentable inventions. de Rassenfosse and van Pottelsberghe (2009) show that both components do matter and should therefore be taken into account. It is nevertheless difficult to collect good indicators of the productivity and this is probably the reason why most studies, including this one, do not distinguish between the two effects.

The estimates control for industry and country effects. For instance, it is frequently found in the literature that Japanese companies have a higher propensity to patent (i.e. a larger number of patents per unit of research input). There is also a strong variation across industries, due to heterogeneous appropriability mechanisms and innovation dynamics. The estimations are performed on Sample 1.

The second set of regressions aims at understanding the impact of the generic motivations on the average family size (quality indicator) of a firm's patent portfolio. The use of the family size as a measure of the average quality of patents deserves a brief discussion. The rationale that the size of patent family is associated with the value of patents is grounded in the empirical literature (see e.g. Guellec and van Pottelsberghe, 2007; Harhoff, Scherer, and Vopel, 2003; OECD, 2009) and has a straightforward explanation. The patenting process is expensive and only high-value inventions are subject to international protection. In fact, the cost of patenting is nearly proportional to the number of countries where a patent is taken (notwithstanding cross-country variations in fees). The assumed relation between cost and value is also the rationale given to other indicators such as the number of years a patent is renewed. The measure of quality we use is thus subjective rather than objective.[8] It reflects how much the firm is willing to spend to have its invention protected in foreign markets. Obviously, a firm will be reluctant to protect its invention in foreign markets if it believes that the associated costs will not be covered by the extra revenues generated. The variable “Family Size” is, however, not a perfect indicator of value as it is also affected by financial resources and the prospect of exporting or not to overseas markets. Hence the need to control for specific characteristics such as whether a firm belongs to a group of companies or its size.

The regressions also include the R&D intensity as a measure of how technologically advanced the representative invention might be. In addition, control dummies for both country and industry effects are included in the model. The estimations are performed on Sample 2 by means of ordinary least squares.

Table 6 goes about here

Some interesting findings emerge from Table 6. Applicants valuing exclusion motives exhibit a higher-than-average propensity to patent (columns (1) and (2)). There is clear evidence of a quantity game, as this motivation is also strongly correlated with the perception of competitors' pressure (see Table 5). Whether the positive impact between the importance of the exclusion motives and competitors' pressure is causal or driven by an unobserved market factor does not change the interpretation: offensive uses of patents lead to greater patent counts. This motivation, however, does not have any direct impact on the quality of patents as illustrated by columns (3) to (5). The positive and significant impact of the number of employees in column (2) indicates that the propensity to patent is higher amongst larger companies.

In a similar vein, the second main motive for patenting, keeping one's own freedom to operate, also substantially affects the propensity to patent. Firms that do rely on the patent system for defensive purposes actually file more patents than the median firm, and a high score on this motivation is also associated with a lower quality, as reported in the second set of regressions. It is an illustration of the trade-off between quantity and quality. Companies that patent for monetary reasons will not exhibit a particular patenting behavior.

Firms that belong to a group tend to file patents with larger families (column 4), reflecting the larger degree of internationalization of groups as compared with smaller or more integrated companies.

The substitution effect between the size of a patent portfolio and its quality is further illustrated by the parameter estimates presented in columns (4) and (5). Controlling for company size, a larger number of priority filings is associated with a lower average family size (see column 4). The result might be a statistical artifact since the dependent variable is the number of second filings per priority filing. Another, more convincing, illustration of the trade-off is provided by the regression presented in column (5). The variable Propensity is the residual from the regression presented in column (2) and captures unobserved patent strategies that lead to a greater propensity to patent. The negative and significant parameter suggests that a company that patents more than predicted by the factors identified in the model also has patents of lower quality. This substitution between quality and quantity has been illustrated in previous works. For instance, Harhoff, Hoisl, and van Pottelsberghe (2009) show that the probability of a patent granted by the EPO being validated in member states is negatively affected by the patentee's portfolio size and positively affected by the number of forward citations the patent receives. At the aggregate level, van Pottelsberghe and van Zeebroeck (2008) observe that the average value of patents filed at the EPO has been constantly decreasing since the mid-eighties, whereas the number of yearly patent filings has exploded.

It is also worth mentioning that Japanese companies have the highest propensity to patent. This result is in line with earlier findings and can be explained by the much narrower scope of Japanese patents (see e.g. Kotabe, 1992). US and German applicants also have a higher than average propensity to patent. Interestingly, no country dummies are significant in the quality equations.

We considered various alternative specifications in order to assess the validity of the results. We estimated the "quantity" equations by means of negative binomial regressions. We also estimated them with ln(PF in 2005 + PF in 2006) as the dependent variable for the sake of consistency with the quality regression. Both specifications lead to very similar results. We also dropped US applicants from both sets of equations as they appeared to be the most important source of bias in the non-response analysis presented in Appendix 8.3. The impact of the motivations was exacerbated, confirming the initial interpretation. Finally, the regressions were also performed by controlling for the restrictive joint clusters with no change in the coefficients (see Appendix 8.1).

6. CONCLUDING REMARKS

This paper analyses the motivations to use the patent system and their impacts on the size and the quality of a firm's patent portfolio. It relies on a large-scale international survey carried out by the European Patent Office. The firms surveyed are those having applied for at least one patent at the EPO, but the worldwide portfolios have been used to conduct the analysis.

The empirical results suggest that a trade-off exists between the quality and the quantity of patent applications and unveil the role played by motivations. Companies that exhibit a high propensity to patent are less likely to have a portfolio of high quality. The trade-off is partly determined by the motivations to patent: companies that file patent applications to protect their freedom to operate adopt a mass-patenting strategy that is detrimental to the quality of their patents.

The analysis also provides interesting insights into firms' motivations to patent, in particular regarding the link with the competitive environment. The exclusion role of patents is the main motivation for filing patent applications. Irrespective of the country, the industry, or the characteristics of the company, a majority of applicants patent for the traditional exclusion motive. This motivation is partly driven by competitors' behavior. Companies that feel that their competitors adopt an aggressive patenting behavior will tend to adopt a similar attitude, suggesting that applicants engage in a patent arms race. This attitude, however, has no noticeable impact on the quality of patent applications. The second most important purpose is to protect one's freedom to operate. A total of 50% of companies patent defensively, which leads to an increase in quantity of patent applications that is detrimental to quality. Monetary motivations are found to be important only to small companies, especially in the pharmaceutical, the biotechnology, and the computer industries. This motivation does not have an impact on the size of the portfolio, nor its quality.

On the policy side, the results have implications regarding how patent offices should react to booming applications. Based on the view that low-quality patents are harmful to the economy and given the fact that there is a clear trade-off between quantity and quality, patent offices could be stricter in granting patents and adopt a more appropriate fee schedule (see in particular van Pottelsberghe (2009) for a discussion). Such a policy would have a strong impact on patent filings. It would deter firms from applying for low-quality patents as their prospect of having the application granted would be extremely low, but it would also lower the need for filing such applications by breaking the inflationary spiral.

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Table 1

The literature on motivations to patent

Motivations to use the patent system …		
Reference	*Key insights*	*Sample*
Levin et al. (1987)	Patents are among the least effective mechanisms of appropriation.	650 business units of US manufacturing firms.
Harabi (1995)	Firms are motivated by other reasons, such as patenting in order to achieve a desirable negotiating position and to enter into foreign markets.	Nine patent attorneys in Switzerland.
Cohen et al. (2000)	Firms patent for reasons that exceed the traditional exclusion motive: patent blocking, use of patents in negotiations, preventing law suits.	1,478 R&D labs in the US manufacturing sector.
Cohen et al. (2002)	Several differences between Japanese and US companies, partly due to their respective patent systems. A greater tendency to use patents for mutual blocking, cross-licensing, and negotiations in Japan.	Both patenting and non-patenting manufacturing firms in Japan (593) and the US (826).
Hall and Ziedonis (2001)	Firms amass vast patent portfolios as "bargaining chips," leading to "patent portfolio races."	Interviews with US semiconductors firms.
Pitkethly (2001)	Significant differences in the motivations to patent between Japanese and UK companies.	211 Japanese and 259 UK patenting firms.
Thumm (2004)	Patents are important for biotechnology SMEs, in particular for raising venture capital.	53 Swiss biotechnology firms.
Blind et al. (2006)	Five groups of motives to patent. Strategic motives are particularly emphasized by large companies.	500 large applicants in Germany.
Giuri et al. (2007)	Firm size and firm type explain a large part of the variation in motivations to patent. The licensing motive is important for SMEs, and patent blocking is mostly favored by large companies.	Inventors of 9,017 patented inventions from 6 EU countries.
Henkel and Pangerl (2008)	Defensive publishing is very popular. A variety of media are used, including the patent system itself.	Interviews with 56 German industrial firms.
Barros (2008)	Firms' motivations to patent differ with respect to their emphasis on either research or development.	56 manufacturing firms in the UK.
Zuniga and Guellec (2009)	Motivations to license out patents differ across firm size. The monetary use of patents is particularly important for small firms.	600 and 1,600 patent holders in Europe and Japan, respectively.
Graham et al. (2009)	Startups patent for capturing competitive advantage, preventing copying, securing financing, and enhancing reputation.	1,332 US-based technology startups.
… and their impact on the patent portfolio		
Reference	*Key insights*	*Sample*
Arundel and Kabla (1998)	The propensity to patent is higher for firms that find patents to be an important method for preventing competitors from copying.	604 European industrial firms.
Duguet and Kabla (1998)	The will of firms to acquire a stronger position in technology negotiations and to avoid trials increases the number of patent applications.	546 French applicants in manufacturing.
Peeters and van Pottelsberghe (2006)	Firms' innovation strategies (academic partnership, collaboration, and product innovation) affect their patenting behavior.	148 large Belgian firms.
Guellec et al. (2008)	Evidence of defensive publishing and patent quality. Applications that have never been cited as making a relevant contribution to the art are those provoking more refusals or withdrawals.	A large set of filings at the EPO.
Blind et al. (2009)	Companies' patenting strategies have an impact on the characteristics of their patent portfolios. The traditional motive of protecting one's own technological knowledge base leads to a higher	500 German applicants.

	number of forward citations. Companies using patents as bartering chips receive fewer citations and less opposition to their patents.

Table 2

Mean score of motivations

Statement	Variable	N	Mean	Mode	[5-6]
I patent mainly to prevent imitation by competitors	Imitation	604	4.60	6	66%
I take more patents in areas where competition is more intense	Competition	596	4.19	5	51%
I use my patents for hampering my competitors' access to technology	Hampering	601	4.18	5	52%
I patent mainly to preserve my freedom of operation	Freedom	602	4.22	5	50%
I take patents in order to convince investors or banks of the value of my inventions	Investors	599	2.83	2	20%
I take patents in view of licensing them out	Licensing	606	3.25	2	25%

Note: The motivations are rated on a 1 (totally disagree) to 6 (fully agree) Likert scale. The column [5-6] indicates the percentage of respondents who selected 5 or 6.

Table 3

Summary statistics and non-response analysis

		Full Sample					*Sample 1*			*Sample 2*		
		N	Mean	Std. Dev.	Min	Max	N	Mean	NRA	N	Mean	NRA
Patents in 2005		696	264	1151	0	18160	330	125	0.03	328	148	0.08
FTE Researchers		405	751	2930	0	47200	330	437	0.06	328	592	0.37
Persons Employed	(o)	613	5.70	1.97	2	9	330	5.28	0.00	328	5.48	0.10
Time Lag		448	10.19	8.73	1	60	330	10.12	0.91	288	9.72	0.46
Group	(d)	594	0.62	-	0	1	324	0.57	0.16	328	0.61	0.66
RD Intensity		398	0.15	0.21	0	1.00	325	0.15	0.72	328	0.15	0.87
Quantity		387	0.85	2.05	0	22.50	319	0.85	0.97	328	0.95	0.58
Quality		669	1.55	3.53	0	56.14	317	1.30	0.24	328	1.40	0.48
Applicant from JP	(d)	696	0.15	-	0	1	330	0.15	-	328	0.19	-
Applicant from US	(d)	696	0.23	-	0	1	330	0.12	-	328	0.12	-
Applicant from GB	(d)	696	0.06	-	0	1	330	0.04	-	328	0.04	-
Applicant from DE	(d)	696	0.22	-	0	1	330	0.27	-	328	0.28	-
Applicant from FR	(d)	696	0.04	-	0	1	330	0.05	-	328	0.05	-

Notes: (o) indicates an ordinal variable and (d) a dummy variable. The variables Group, R&D Intensity, Quantity, and Quality are not used in Sample 1; it thus has no importance that the number of observations in this sample is lower than 330. Similarly, Time Lag is not used in sample 2. NRA stands for “non-response analysis” and reports the p-value for a test of difference in means with the full sample. Individual inventors and public entities have been excluded from all the samples. The two subsamples are driven by data availability.

Table 4

Polychoric correlation matrix of the various statements

	(1)		(2)		(3)		(4)		(5)		(6)
(1) Imitation	1										
(2) Competition	0.29	***	1								
(3) Hampering	0.45	***	0.40	***	1						
(4) Freedom	0.14	***	0.22	***	0.07	*	1				
(5) Investors	-0.02		-0.04		0.02		0.07	*	1		
(6) Licensing	-0.18	***	-0.04		-0.14	***	-0.04		0.45	***	1

Notes: ***, **, and * respectively indicate the 1%, 5%, and 10% thresholds of the p-value associated with the likelihood ratio test of no correlation.

Table 5

Determinants of the motivations sto patent

		(1) Imitation	(2) Competition	(3) Hampering	(4) Freedom	(5) Investors	(6) Licensing
My competitors hamper	(o)	0.17***	0.21***	0.62***	0.07	0.03	0.05
		(3.34)	*(4.25)*	*(8.56)*	*(1.60)*	*(0.71)*	*(0.97)*
Time lag		-0.01	-0.02*	-0.01	-0.00	0.01	0.00
		(0.91)	*(1.91)*	*(0.64)*	*(0.07)*	*(1.13)*	*(0.11)*
SME	(d)	0.06	-0.10	0.21	0.08	0.60***	0.33**
		(0.39)	*(0.65)*	*(1.28)*	*(0.59)*	*(3.75)*	*(2.19)*
Large company	(d)	0.08	0.33*	-0.06	0.25	-0.03	-0.25
		(0.50)	*(1.89)*	*(0.38)*	*(1.23)*	*(0.21)*	*(1.48)*
FTE researchers		-0.08	0.04	0.03	-0.02	-0.14*	0.07
		(1.04)	*(0.66)*	*(0.41)*	*(0.16)*	*(1.86)*	*(0.82)*
Country (ref = other)							
JP		0.48**	0.74***	0.40*	0.67***	-0.00	0.10
		(2.17)	*(3.58)*	*(1.96)*	*(3.16)*	*(0.01)*	*(0.50)*
US		0.27	-0.08	-0.40	0.12	0.00	0.09
		(1.38)	*(0.41)*	*(1.58)*	*(0.57)*	*(0.02)*	*(0.42)*
GB		0.03	-0.14	0.25	0.04	0.68***	0.46
		(0.07)	*(0.46)*	*(0.70)*	*(0.15)*	*(2.80)*	*(1.28)*
DE		0.23	-0.04	0.42***	0.01	-0.11	-0.19
		(1.45)	*(0.26)*	*(2.95)*	*(0.04)*	*(0.63)*	*(1.19)*
FR		0.25	0.13	0.53	0.68**	0.43*	0.35
		(0.94)	*(0.34)*	*(1.61)*	*(2.32)*	*(1.66)*	*(1.15)*
Joint clusters							
JC1 – Media		-0.01	-0.58*	-0.09	-0.10	0.48*	0.29
		(0.02)	*(1.91)*	*(0.34)*	*(0.31)*	*(1.71)*	*(0.97)*
JC2 – Biotechnology		0.17	-0.11	-0.01	-0.06	0.22	0.43**
		(0.66)	*(0.49)*	*(0.03)*	*(0.28)*	*(1.13)*	*(1.98)*
JC3 – Civil Engineering		0.56**	0.38	0.88***	-0.07	-0.26	-0.17
		(2.32)	*(1.57)*	*(2.94)*	*(0.32)*	*(0.98)*	*(0.70)*
JC4 – Computers		0.35	0.99***	0.16	-0.57*	0.44	0.86***
		(1.01)	*(3.15)*	*(0.54)*	*(1.94)*	*(1.08)*	*(2.62)*
JC7 – Handling & Processing		0.12	0.17	0.22	-0.03	-0.40**	-0.22
		(0.70)	*(0.91)*	*(1.35)*	*(0.15)*	*(2.14)*	*(1.32)*
JC8 – Human necessities		0.08	-0.20	0.23	0.04	-0.42***	-0.19
		(0.46)	*(1.26)*	*(1.58)*	*(0.20)*	*(2.68)*	*(1.20)*
JC11 – Polymers		0.11	-0.00	0.06	-0.39	0.29	-0.38*
		(0.41)	*(0.02)*	*(0.30)*	*(1.31)*	*(0.83)*	*(1.70)*
JC12 – Organic Chemistry		0.23	0.31	0.02	0.05	0.57**	0.44*
		(0.66)	*(1.51)*	*(0.08)*	*(0.17)*	*(2.45)*	*(1.74)*
JC13 – Telecommunications		-0.76***	-0.34	-0.79***	0.40	-0.10	0.44*
		(2.78)	*(1.60)*	*(2.66)*	*(1.46)*	*(0.42)*	*(1.83)*
JC14 – General Technology		0.07	0.01	0.31*	0.07	-0.09	0.01
		(0.42)	*(0.08)*	*(1.84)*	*(0.40)*	*(0.60)*	*(0.09)*
Pseudo R2		0.04	0.07	0.20	0.03	0.07	0.04
Polyserial R2		0.14	0.23	0.52	0.11	0.22	0.17
Observations		330	330	330	330	330	330

Notes: Dependent variables are the Likert-scaled variables on agreement towards motivations to patent, from Sample 1. The variable “My competitors hamper” is a Likert-scale variable reciprocal to the motivation “Hampering.” “SME” and “Large” are dummy variables constructed from “Persons Employed,” taking the value of 1 if the number of employees is lower than 250 and greater than 10,000, respectively. The econometric method used is ordered probit with robust z-statistics (reported in parentheses). ***, **, and * indicate significance at the 1%, 5%, and 10% probability thresholds, respectively. “Polyserial R2” is the square of the polyserial correlation coefficient between the dependent variable and its predicted value. All industry dummies (non-restrictive methodology, see Appendix 8.1) were included in the regressions but only significant dummies are reported.

Table 6

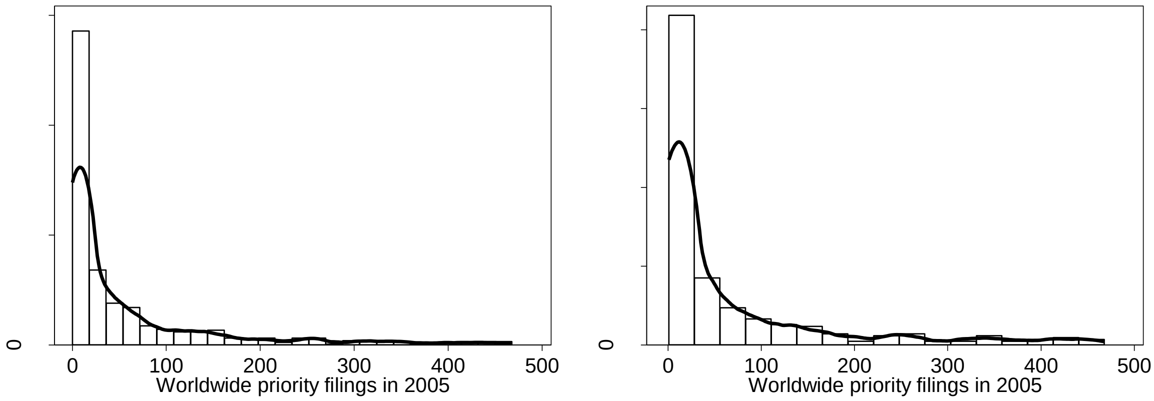
Determinants of the propensity to patent and the family size

	(1)	(2)	(3)	(4)	(5)
	Quantity		Quality		
ln FTE researchers	0.21***	0.17***			
	(20.70)	*(11.67)*			
Number of employees		0.06***	-0.10	-0.04	-0.11
		(3.37)	*(1.02)*	*(0.45)*	*(1.18)*
Group (d)		-0.00	0.76**	0.74**	0.76***
		(0.03)	*(2.45)*	*(2.43)*	*(2.63)*
R&D intensity			-0.75	-0.72	-0.91
			(0.96)	*(0.94)*	*(1.25)*
PF in 2005				-0.00**	
				(2.43)	
Propensity (residuals of (2))					-0.84***
					(6.40)
Motivations (score on factorial axes)					
Exclusion	0.04**	0.03*	0.16	0.18	0.16
	(2.14)	*(1.87)*	*(1.15)*	*(1.24)*	*(1.18)*
Monetary	-0.00	0.01	-0.07	-0.06	-0.06
	(0.14)	*(0.49)*	*(0.44)*	*(0.39)*	*(0.42)*
Freedom	0.08**	0.07**	-0.30*	-0.30*	-0.30*
	(2.49)	*(2.27)*	*(1.71)*	*(1.70)*	*(1.81)*
Country (ref = other)					
JP	0.35***	0.36***	0.01	0.31	0.01
	(6.52)	*(6.76)*	*(0.02)*	*(0.69)*	*(0.03)*
US	0.16***	0.14**	0.54	0.51	0.53
	(2.66)	*(2.38)*	*(1.11)*	*(1.06)*	*(1.16)*
GB	-0.22	-0.22	-0.25	-0.36	-0.26
	(1.55)	*(1.56)*	*(0.36)*	*(0.51)*	*(0.39)*
DE	0.11**	0.10*	-0.33	-0.34	-0.33
	(2.07)	*(1.93)*	*(0.92)*	*(0.96)*	*(0.98)*
FR	-0.08	-0.08	0.44	0.43	0.44
	(0.64)	*(0.65)*	*(0.66)*	*(0.65)*	*(0.70)*
Joint clusters					
JC2 – Biotechnology	-0.21***	-0.17**	0.65	0.71	0.67
	(2.83)	*(2.29)*	*(1.33)*	*(1.47)*	*(1.46)*
JC4 – Computers	0.12*	0.13**	-0.86	-0.49	-0.86
	(1.76)	*(2.10)*	*(1.02)*	*(0.58)*	*(1.07)*
JC9 – Industrial Chemistry	0.10*	0.09*	0.10	0.18	0.11
	(1.72)	*(1.77)*	*(0.22)*	*(0.40)*	*(0.26)*
JC13 – Telecommunications	-0.03	-0.03	2.51***	2.87***	2.52***
	(0.35)	*(0.40)*	*(4.09)*	*(4.59)*	*(4.37)*
JC14 – General Technology	0.02	0.01	-0.70*	-0.63*	-0.69**
	(0.59)	*(0.36)*	*(1.88)*	*(1.69)*	*(1.97)*
Constant	0.05	-0.12	1.63***	1.36**	1.69***
	(0.69)	*(1.38)*	*(2.78)*	*(2.29)*	*(3.07)*
Pseudo R2	0.23	0.23	0.11	0.13	0.22
Observations	328	328	328	328	328

The dependent variable is the number of priority filings in 2005 taken to the log in columns (1) and (2) and the family size in columns (3) to (6), from Sample 2 The econometric methods used are pseudo maximum likelihood (Poisson density) with robust standard errors in columns (1) and (2) and ordinary least square in columns (3) and (4). ***, **, and * indicate significance at the 1%, 5%, and 10% probability thresholds, respectively. All industry dummies (non-restrictive methodology, see Appendix 8.1) were included in the regressions but only significant dummies are reported.

Figure 1

Density function of the number of priority filings in 2005 (variable "Patents in 2005")



Note: the data are truncated for ease of readability to portfolios larger than 500. The left and the right panels are based on the full sample and Sample 2, respectively.

8. APPENDICES

8. 1 Description of joint clusters

Table 7 – A description of EPO's joint clusters

Code	Short name	Full name
JC1	Media	Audio, Video and Media
JC2	Biotechnology	Biotechnology
JC3	Civil Engineering	Civil Engineering; Thermodynamics (incl. engines and pumps)
JC4	Computers	Computers
JC5	Electricity and Semiconductor	Electricity and Semiconductor Technology
JC6	Electronics	Electronics
JC7	Handling and Processing	Handling and Processing
JC8	Human Necessities	Human Necessities (incl. agriculture, medical products, printing)
JC9	Industrial Chemistry	Industrial Chemistry
JC10	Measuring and Optics	Measuring and Optics
JC11	Polymers	Polymers
JC12	Organic Chemistry	Pure and Applied Organic Chemistry (incl. pharmaceuticals)
JC13	Telecommunications	Telecommunications
JC14	General Technology	Vehicles; General Technology (incl. transporting mechanisms, lighting)

Two methods have been used to identify the joint cluster(s) companies belong to. The first one relies on companies' assessment of their main area(s) of business. This method, which will be called *non-restrictive*, allows companies to be listed in as many as 14 industries. In practice, however, less than 2% of companies reported being active in more than 4 industries, as indicated in Table 8. The second method uses information on R&D dollars spent in each joint cluster to assess a company's most important business area. Note that this restrictive methodology results in 30% of companies not being linked with any joint cluster due to missing information on the breakdown of R&D expenditures. For that very reason, the analyses are presented using the non-restrictive methodology.

Table 8

Distribution of the number of joint clusters for the non-restrictive and the restrictive methodologies

Total joint clusters	*Non-restrictive*	*Restrictive*
0	2.73	30.30
1	71.52	66.36
2	14.85	1.82
3	6.06	0.61
4	3.64	0.30
5	0.30	0.30
6	0.61	0.30
14	0.30	0.00

Note: the data are computed for Sample 1 and are very similar for Sample 2.

8.2 Summary statistics broken down by industries

Table 9

Mean of motivations, by joint cluster

Joint cluster:	N	Imitation	Competition	Hampering	Freedom	Investors	Licensing
JC1 – Media	30	4.50	4.30	3.80	4.60	3.30	4.10
	11	5.40	4.10	4.00	4.60	3.50	3.40
JC2 – Biotech.	90	4.00	3.70	3.60	3.80	3.50	4.40
	37	4.40	3.50	3.70	4.10	4.20	4.10
JC3 – Civil Eng.	64	4.60	4.20	4.30	4.40	2.60	3.40
	25	5.10	4.20	4.90	4.40	2.60	2.80
JC4 – Computer	33	4.00	4.30	3.30	4.00	3.30	4.70
	4	4.70	4.70	4.20	4.70	3.50	4.50
JC5 – Electricity	100	4.20	4.30	4.10	4.30	2.90	3.60
& Semiconductor	38	4.30	4.20	4.40	4.30	2.90	3.00
JC6 – Electronics	69	4.00	4.20	3.80	4.30	2.90	3.70
	22	4.00	4.00	3.80	4.30	2.80	3.00
JC7 – Handling	88	4.80	4.50	4.60	4.40	2.40	2.90
& Processing	37	4.90	4.50	4.70	4.10	2.20	2.80
JC8 – Human	127	4.50	4.10	4.10	4.10	2.70	3.50
Necessities	53	4.60	4.20	4.50	4.20	2.80	3.10
JC9 – Ind. Chemistry	79	4.60	4.20	4.20	4.10	3.10	3.60
	31	5.10	4.00	4.50	3.90	3.20	2.90
JC10 – Measuring	68	4.30	4.00	4.00	4.20	2.80	3.60
& Optics	21	4.80	4.00	4.30	4.20	2.50	3.10
JC11 – Polymers	59	4.20	4.20	4.10	4.00	3.00	3.60
	13	4.50	4.10	4.50	3.50	1.90	2.50
JC12 – Org. Chemistry	76	4.10	4.20	3.70	3.90	3.10	4.00
	20	4.60	4.60	4.00	4.40	3.10	3.40
JC13 – Telecom.	50	4.00	4.30	3.40	4.70	2.80	4.10
	15	4.10	4.60	3.50	4.80	2.60	4.10
JC14 – General Tech.	110	4.70	4.40	4.40	4.50	2.50	3.00
	40	4.80	4.40	4.50	4.30	2.50	2.90

Notes: the column 'N' refers to the mean sample size. The first and the second rows of each joint cluster report data for the non-restrictive and the restrictive methodologies, respectively (see Appendix 8.1).

Table 10

Summary statistics, by joint cluster

Joint cluster:	N	(1) Time Lag	(2) RD Intensity	(3) Quantity	(4) Quality	(5) Corr[(3),(4)]
JC1 – Media	26	10.40	0.25	0.65	1.10	-0.23
	9	8.20	0.20	0.60	1.35	-0.33
JC2 – Biotech.	77	15.05	0.35	0.55	1.80	-0.18
	33	18.50	0.35	0.90	1.45	-0.21
JC3 – Civil Eng.	48	12.15	0.45	1.20	2.20	-0.36
	23	9.20	0.50	1.70	1.05	-0.40
JC4 – Computer	28	14.15	0.35	0.40	1.00	-0.26
	3	15.00	0.20	0.35	1.35	-0.01
JC5 – Electricity	83	11.15	0.20	1.00	1.70	-0.06
& Semiconductor	30	9.15	0.20	0.90	1.45	-0.21
JC6 – Electronics	57	10.35	0.25	1.05	1.90	-0.04
	20	9.35	0.15	0.85	1.30	-0.15
JC7 – Handling	75	8.30	0.15	0.70	1.05	0.12
& Processing	35	8.25	0.15	0.90	1.40	0.12
JC8 – Human	109	13.35	0.20	1.10	1.30	-0.21
Necessities	49	15.65	0.20	0.95	1.15	-0.21
JC9 – Ind. Chemistry	68	14.55	0.30	0.55	1.50	-0.10
	28	11.10	0.25	0.75	1.50	-0.23
JC10 – Measuring	56	11.75	0.20	0.90	1.90	0.01
& Optics	20	11.00	0.15	0.75	1.35	-0.11
JC11 – Polymers	48	14.65	0.30	0.30	1.85	-0.05
	11	8.80	0.20	0.35	2.20	-0.40
JC12 – Org. Chemistry	57	15.40	0.30	0.20	2.40	-0.14
	18	13.15	0.25	0.20	2.50	-0.32
JC13 – Telecom.	42	12.60	0.30	0.80	1.65	-0.11
	12	8.85	0.20	0.60	3.85	-0.32
JC14 – General Tech.	94	10.75	0.15	0.75	1.35	-0.08
	40	9.00	0.10	0.70	1.15	0.01

Notes: the column 'N' refers to the mean sample size. The first and the second rows of each joint cluster report data for the non-restrictive and the restrictive methodologies, respectively (see Appendix 8.1).

8.3 Non-response analysis

The elements of non-response analysis presented in Table 3 suggest that the means of the various variables computed on the observations in the full sample sometimes differ from those computed on the observations included in Samples 1 or 2. Table 11 presents the determinants of the probability that a firm is included in the subsamples. Large applicants were relatively more likely to skip the questionnaire, as indicated by the negative and significant impact of the variable "Patents in 2005." A similar observation can be made for US and GB applicants.

Table 11

Bivariate probit analysis of determinants of inclusion in the restricted samples

	(1)	(2)
Dep. Variable:	In Sample 1 (d)	In Sample 2 (d)
Patents in 2005	-0.00***	-0.00***
	(2.70)	*(2.93)*
US	-0.80***	-0.75***
	(5.56)	*(5.19)*
JP	-0.16	0.28
	(0.91)	*(1.54)*
GB	-0.57**	-0.45**
	(2.53)	*(1.97)*
DE	0.03	0.17
	(0.19)	*(1.22)*
FR	0.22	0.23
	(0.84)	*(0.88)*
Constant	-0.01	-0.20*
	(0.12)	*(1.76)*
Pseudo R2	0.11	0.12
Observations	696	696

Notes: the dependent variable is a dummy variable taking the value of 1 if the observation is included in the sample. The econometric method used is probit analysis. Robust z-statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% probability thresholds, respectively. All industry dummies were included in the regressions.

The result might thus be slightly biased due to missing values for large applicants and applicants from Great Britain and the US. The problem is nevertheless more acute for US applicants, who account for 23% of the total applicants in the full sample but only for 12% in the restricted samples (see Table 3). In the next table, we report the mean score of the variables' motivations as a function of whether the companies are included or not in Sample 2.

Table 12

Mean score of motivation according to whether the company is included or not in Sample 2

	in Sample 2	not in Sample 2	
Imitation	4.75	4.45	**
Competition	4.25	4.10	
Hampering	4.40	3.95	***
Freedom	4.25	4.20	
Investors	2.75	2.95	
Licensing	2.95	3.60	***

Note: ***, **, and * indicate a difference in means at the 1%, 5%, and 10% probability thresholds, respectively.

Applicants excluded from Sample 2 were relying less on patents to prevent imitation and for hampering their competitors. On the contrary, they seem to be relying more on the licensing motivation. Since the problem seems to concern mostly US applicants, the regressions of Table 6 will be performed on a subsample from which US applicants are excluded as a robustness test.

8.4 Factor analysis of the motivations to patent

Table 13 reports the results of a principal component analysis performed on the polychoric correlation matrix of the motivations to patent. The first three factors capture more than 70% of the variation of the data.

Table 13

Summary of the PCA analysis

Factors	Eigenvalues	Proportion explained	Cumulative proportion
1	1.90	0.32	0.32
2	1.41	0.23	0.55
3	0.95	0.16	0.71
4	0.73	0.12	0.83
5	0.54	0.09	0.92
6	0.47	0.08	1.00

The correlations between the three first score variables and the motivations are reported in Table 14. It clearly appears that the first variable is mostly correlated with the statements Imitation, Competition, and Hampering, while the second is strongly correlated with the Investors and Licensing motives. Finally, the third score mostly captures the freedom to operate motivation.

Table 14

Correlation coefficients between factors and motivations

	Factor 1	Factor 2	Factor 3
Imitation	**0.72**	0.10	-0.21
Competition	**0.65**	0.24	0.10
Hampering	**0.72**	0.18	-0.34
Investors	-0.18	**0.77**	-0.09
Licensing	-0.39	**0.71**	-0.10
Freedom	0.33	0.28	**0.86**

This result is intuitive and suggests that motivations can be grouped into three categories. The first one would be the traditional motive of protecting from imitation and competitive pressure. The second motivation is related to the monetary use of patents: either to be licensed out or to attract investors. Finally, patenting in order to keep one's own freedom to operate is a third distinct motive.

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[1] The complete description of the survey is available on the following website: http://www.epo.org/patents/APS.html.

[2] The categories are as follows: 1:1, 2:2–9, 3:10–49, 4:50–249, 5:250–999, 6:1,000–4,999, 7:5,000–9,999, 8:10,000–49,999, 9:50,000+ employees.

[3] Since the number of employees is an ordinal variable, the middle class value was used to compute the ratio, except i) for the last category, where data on the number of employees were collected from online sources such as annual reports and ii) when the middle class value gave an intensity higher than 1, the maximal value of the class has been used.

[4] It could be argued that an alternative measure of quality would be the ratio of second filings in 2006 over priority filings in 2005 since the Paris Convention allows a one-year period of priority right. Priority filings in 2005 can, however, lead to second filings in 2005, which is what the variable somehow controls for.

[5] The motives are orthogonal to each other by construction. Yet, exclusion is a necessary condition to earning revenues from patents, such that the two motives should not be mutually exclusive. This contradiction is only apparent since a patent taken in order to generate financial resources also confer the exclusion needed to exploit the technology. The factor analysis presents the *main* motivations of the respondent.

[6] The exact wording of the statement is: "My competitors use their patents for hampering my access to technology."

[7] The non-restrictive methodology assigns joint clusters according to companies' self-assessment of their main area(s) of business. In contrast, the restrictive methodology consider the main business area(s) as those where the largest amount of R&D expenditure is invested (see Appendix 8.1).

[8] An objective measure of quality would be, for instance, the number of forward citations received. It is the ex-post realisation of what the quality really is, instead of the ex-ante belief, and therefore does not fit our purpose very well. Note that the two measures are found to be highly correlated with each other.