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How SMEs Exploit Their Intellectual Property Assets: Evidence from Survey Data

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Abstract

This paper seeks to understand how motives to patent affect the use of the patent portfolio with a particular focus on motives aimed at the monetization of intellectual property (IP). The analysis relies on data from an international survey conducted by the European Patent Office (EPO). The main results can be summarized as follows. First, small and medium-sized enterprises (SMEs) exhibit a much stronger reliance on 'monetary patents' than large companies and nearly half of the SMEs in the sample patent for monetary reasons. Second, SMEs tend to use their patents more actively than large firms. Third, smaller companies generally have a higher proportion of their portfolio that is licensed but the licensing rate is significantly higher in the U.S. An American SME is twice as likely as a European SME to have a high share of its portfolio that is actually licensed, witnessing a fragmented market for technology in Europe.

JEL Classification: O32, O34, O38, G21, G24

Keywords: Financing constraint, intellectual property strategy, market for technology, motives to patent, multivariate ordered models, technology licensing

1. Introduction

This paper seeks to explain *how SMEs' motivations to patent affect the use of the patent portfolio*, with a particular focus on motives aimed at the monetization of intellectual property (IP). If practices such as sales and license-back of patents or securitization of IP rights seem currently inaccessible to SMEs, two motives to patent are of particular interest: to attract banks or investors and to generate revenues from licensing deals. The understanding of the signalling effect of patents for venture capital and the determinants of licensing has progressed in the literature, but little is known on the utilization of IP in SMEs. In particular, an assessment of the utilisation of 'monetary patents' is lacking; that is patents that are taken to attract investors or to generate licensing revenues. In this respect, the paper takes a detailed look at the role played by these two key motives. The analysis relies on an original dataset based on an international survey carried out in 2006 by the European Patent Office (EPO).

This paper builds on several well-known surveys. The first of which is the Carnegie-Mellon University survey by Cohen et al. (2000) which investigates the *motives for patenting* of U.S. firms. An overwhelming majority of respondents patent to protect against imitation and to block competitors, and roughly 30% take patents to generate licensing revenues. A second contribution is Blind et al.'s (2006) comprehensive survey on 15 motives to patent in German companies. It provides additional information on monetary motivations: 26% of the companies surveyed take patents to access capital markets and 21% to generate revenue from license. The authors performed a factor analysis of the various motivations to patent and found that these two motives were highly correlated with each other; they grouped these two motives into a broader 'exchange' motive. They then present econometric evidence that the exchange motive is more important for large firms, which is surprising at least as far as the 'access to the capital market' motivator is concerned. A third survey is the PatVal-EU survey on inventor, which provides information on the actual *uses of patents* (Giuri et al. 2007). The analysis shows that large companies trade less than 10% of their patent portfolio and leave 40% of their patents unused. These figures are in sharp contrast with those for medium companies, for which it is estimated that 65% of the patents are actively used, about 10% are traded, and 25% are left unused. Small companies reveal that more than 25% of their patents are traded and less than 20% are unused. Firm size thus seems to be an important determinant of the extent to which the patent portfolio is used or licensed.

The three main results can be summarized as follows. Firstly, descriptive statistics confirm earlier findings. We show, among other things, that the monetary (or exchange) motives are highly important to SMEs. Nearly half of SMEs in the sample take patents for monetary reasons. Although the main motivation to patent is to protect against imitation, SMEs consistently report a higher reliance on patents to attract investors or to earn licensing revenues as compared with larger companies. SMEs also have a higher proportion of their patent portfolio that is licensed and have a lower share of patents that are unused. Secondly, the estimation of trivariate ordered probit regression models of the determinants of the use of the patent portfolio leads to the conclusion that companies that take patents to convince investors have a lower share of their patent portfolio that is not used and use more of their patents internally. However, the effect is weaker for SMEs, which may suggest that some SMEs face difficulties in finding the necessary resources to exploit their inventions. Companies that take patents in view of licensing them out have, as expected, a greater share of their portfolio that is licensed. However, they also have a greater share of their portfolio that is not used, probably due to difficulties in finding potential licensees. Thirdly, the licensing rate is significantly higher in the U.S. than in Europe. We estimate that a U.S.

company that is willing to license is twice as likely, as a European SME willing to license, to have a high share of its portfolio that is actually licensed. These results suggest inefficiencies in the European market for technology.

The paper is structured as follows. The next section discusses the rationales for the monetary uses of patents and reviews the empirical literature. Section 3 presents the data as well as some descriptive statistics. The results are analyzed and interpreted in Section 4. Section 5 concludes and puts forward policy implications to strengthen the monetary role of patents for SMEs.

2. Literature review

This section is articulated in three parts. First, the main problems associated with the financing of R&D are presented and it is explained how patents can contribute to mitigating them. The second and the third parts review the literature on patent licensing and on patenting to access capital markets, respectively.

2.1 Patents and the financing of innovation

From a theoretical point of view, investment in R&D is subject to various imperfections.[1] Strong *asymmetric information* is one of them. The inventor is more knowledgeable than the potential investor about the likelihood of success and the market potential of his project. Investors are unable to differentiate between good and bad projects and will therefore require a high premium for R&D investments. A second imperfection is related to *agency costs*. The separation of management and ownership creates a principal-agent problem, where managers are typically more risk averse than investors (Hall 2002). They are keener to avoid bankruptcy and will therefore frown upon projects that are too risky, leading to a suboptimal level of investment in R&D. It is often heard that dollars for R&D projects are probably the most expensive investment dollars that a company can raise. Since the firm's cost of external capital is high, internal capital often appears as the preferred source of investment in research activities.

The internal financing of R&D is, however, limited by the financing constraints faced by the company. These constraints are often acute for SMEs, which lack a stable and high enough level of cash flow (see Czarnitzki and Hottenrott 2010, for recent empirical evidence). As a consequence, SMEs cannot afford to finance innovation internally and generally turn to external sources of capital and pay the high premium required. Companies that lack physical assets or cannot show a significant track record will most likely face higher difficulties in getting access to loans. R&D investment, indeed, leads to intangible assets that banks and bondholders can hardly use as collateral.

Yet, SMEs can leverage their IP to facilitate R&D financing. In light of the above discussion, there are two ways in which patents can help finance innovation.[2] Patents can be used: i) to

[1] Excellent reviews on the financing of innovation are provided by Hall (2002; 2009) and Harhoff (2009). See also Myers and Majluf (1984) for a theoretical discussion on the financing of investments.

[2] It may seem counter-intuitive that a firm facing financial constraints will engage in patenting. After all, one may think that a company that lacks money to invent will also lack money to patent – if it has any invention to patent at all. Obviously, 'monetary patenting' can occur only if the firm: i) has an invention that meets the patentability requirements; and ii) has money to patent. Given that patenting costs are a fraction of R&D costs, it

reduce the cost of external capital; and ii) to generate additional cash flows. The rationale for the former effect is twofold. First, patents can serve as a credible signal that reduces information asymmetry. By taking patents on promising innovations, the inventor reveals some information to investors. This information will make investors more able to differentiate between good and bad projects. By so doing, the inventor can negotiate more favourable financing conditions. Second, patents materialize the value of knowledge stock: they codify the knowledge and make it tradable, such that they can be used as collaterals. Recent theoretical evidence by Amable et al. (2010) suggests that a systematic use of patents as collateral would allow a high growth rate of innovations despite financial constraints. However, one has to admit that patents are difficult to trade. The difficulties in assessing a patent's exact value and in finding potential buyers make it a rather illiquid asset. The rationale for the latter effect is obvious. Taking patents in view of licensing them out is a way to generate additional cash flows from licensing deals, especially in the absence of the complementary assets needed to exploit the invention internally (such as distribution channels or marketing competencies).

Various monetization techniques have emerged over the recent past (see, e.g. Guellec et al. 2007; Harhoff 2009; Huston 2004; McClure 2009; O'Haver 2003). In addition to outward licensing, the sale and license-back of IP rights or IP securitization are two techniques that companies can use.[3] A fourth alternative to generate extra revenues for patents consists of selling them, particularly if they belong to non-core IP (i.e. IP that is not essential to the conduct of the main business activity of the firm). These monetization techniques, however, are often too complex and costly to implement for SMEs. The sale and license-back of IP, for instance, requires a significant deal size to support the amount of due diligence needed. The securitization of royalty streams is also out of reach for most SMEs as such deals are very complex and typically require a history of the IP asset. Taking patents in view of licensing them out and of convincing investors or banks are the most likely monetary uses for SMEs. This is the reason why the paper focuses on these two aspects.

2.2 Patenting for outward licensing

The monetary uses of patents are overlooked by the literature on strategic patenting. Yet, there is evidence that the market for technology is growing fast. Arora et al. (2001) estimate the world market for technology to have been about US$35–50 billion in the mid-1990s (including licenses, licenses involving know-how and other collaboration such as production and marketing), with a large part being located in the U.S. Assuming that a constant share of innovation is licensed, Guellec et al. (2007) argue that the licensing market should have evolved roughly in line with business R&D expenditures and estimate it to have been around US$55–75 billion in the mid-2000s. Athreye and Cantwell (2007) report that worldwide royalty and license revenues were over US$90 billion in 2003, which is in accordance with a more recent estimate published by *The Economist* (2005), valuing technology licensing revenues at around US$100 billion in 2005 (and US$45 billion in the U.S. alone). However, as pointed out in Harhoff (2009), the overall monetary value of licensing transactions over-

is realistic to assume that a firm facing financial constraints may have some money left to apply for a patent – the last $5,000 that a firm can spend on R&D may be more valuable if it is spent on patenting.

[3] Sale and license-back is very similar in spirit to the sale and lease-back of capital equipment. Put simply, the owner of the assets sells the IP to the investor and takes a license back to use the IP. This mechanism has fiscal advantages for the initial patent holder. The securitization of IP rights typically consist of transferring the royalty stream of one or several IP assets to a bankruptcy remote vehicle which, in turn, issues securities to investors. David Bowie's US$55 million deal and Guess? Inc.'s trademarks securitization are well known examples (Huston 2004).

estimates the actual extent of genuine market exchange. Some of the market transactions, indeed, may be driven by within-multinational group technology trade for tax optimization purposes or by the willingness to avoid costly litigation in case of patent infringement.

In fact, licensing has become attractive to firms for several reasons, as reflected by the survey conducted by Lichtenthaler (2007) on large companies. Firms license their technology for three broad groups of motives: i) *product oriented motives* such as entering into foreign markets, selling additional products or setting standards; ii) *technology oriented motives*, especially guaranteeing freedom to operate (the most important motive in the survey), obtaining access to another company's technology portfolio and guaranteeing technological leadership; and finally iii) *mixed strategic motives*, which represent the least important motive (enhancing reputation, strengthening inter-organizational networks, etc.). The motive of generating revenues has been ranked the seventh most important for outward licensing. Young companies, on the contrary, rate earning revenues as the main motivation to license out patents to third parties (Zuniga and Guellec 2009).

The empirical literature has started investigating the various profiles of licensors and the main determinants of licensing. In an attempt to understand the various characteristics of licensing contracts, Anand and Khanna (2000) confirm the general perception that the majority of licensing contracts are found in the chemical, computer and electronics industries.

Within industries, *firm size* appears to be one of the most important determinants of licensing: small firms are generally more likely to license than large firms. This result has been confirmed by many authors (see e.g. Arora and Ceccagnoli 2006; Gambardella et al. 2007; Motohashi 2008). One of the reasons often put forward relates to the *complementary assets* required to commercialize a new technology (such as manufacturing and marketing capabilities): small firms generally lack such assets and therefore prefer licensing their technology to appropriate the returns to innovation, especially when these assets are costly to acquire. Nevertheless, Motohashi (2008) and Nagaoka and Kwon (2006) both suggest that licensing propensity is also high for very large firms, due to the effect of cross-licensing. This U-shaped relationship has also been observed by Zuniga and Guellec (2009).

The *structure of the competitive environment* seems to be another determinant of the rate of licensing. For example, Gambardella et al. (2007) find that licensing is more likely the greater the protection, the more codified or general the knowledge, and the more potential technology suppliers there are. In a similar vein, Fosfuri (2006) analyzes a survey of large firms active in the chemical industry and points out that the rate of licensing is initially increasing and then decreasing in the number of potential technology suppliers, negatively related to the licensor's market share and to the degree of product differentiation. In short, the more favourable the competitive position of the firm, the less likely that it will license its technology. Intuitively, firms with strong market power may be better positioned to generate revenues from their inventions than potential licensees. As start-ups are generally in a weak competitive position, this argument also explains why small firms generally license more than large firms.

2.3 Patenting in order to get better access to capital market

Evidence on the use of IP to improve a firm's access to external capital is scarce and often relates to the signalling effect of patents. Analyzing venture-backed start-ups in the software industry in the U.S., Mann and Sager (2007) find that patent acquisition is 'significantly

correlated with any of several variables that are indicators of the firm's progress through the venture capital (VC) cycle (including number of rounds, total investment, and longevity)'. As the firm matures and starts generating revenues, patents become increasingly important for VC companies. The idea that patents can act as a credible signal to investors finds favourable echoes in Lemley (2000), Hsu and Ziedonis (2008) and Haeussler et al. (2009). For instance, Haeussler et al. (2009) show that VC financing of biotechnology start-ups occurs earlier in the presence of patent applications. Hsu and Ziedonis (2008) find a significant effect of patents on investor estimates of start-up firm value. The signalling effect is greater in earlier financing rounds.

Signalling the value of IP to attract financing is often more important for SMEs than for larger firms for the mere reason that SMEs often have fewer other assets of value (OECD, 2005). According to the Organisation for Economic Co-operation and Development (OECD), the use of IP as a collateral for bank loans is still a limited practice. For example, a survey of about 50 European commercial banks found none that routinely accept intangible assets as collateral for loans to new technology-based firms, mainly because commercial banks are not confident in the realization of the value of IP (European Commission, 2000). In a similar vein, Freel (2006) finds that small innovators in the UK that apply for bank loans are credit-constrained relative to their less- and non-innovative peers.

Monetary patents can thus be particularly valuable to SMEs, but an assessment of how popular monetary patents are and how SMEs use their patent portfolio is lacking. The present paper contributes to the literature in two ways: it provides statistics on SMEs' motivations to apply for patents and presents an analysis of the determinants of the use of the patent portfolio, with a particular focus on the effect of monetary motives.

3. Data and descriptive statistics

The analysis uses data from an international survey carried out from June to September 2006 by the EPO. The main purpose of the survey is to provide information on filing intentions for the EPO's forecasting exercise. Besides information on filing intentions, which are not reported here, a part of the survey was dedicated to the motivations to use the patent system and to how companies exploit their patent portfolios.

The population is composed of all the applicants who filed a patent application at the EPO in 2005. Applicants were selected in two groups: the Biggest group (405 participants who filed the largest number of patents in 2005) and the Random group (1973 participants). There were a total of 2,098 distinct applicants selected (with an overlap of 280 applicants from the Biggest group who also appeared in the Random group), covering about 31% of the total applications at the EPO. Since applicants from the Random group are obtained from a simple random sample of applications, it must be noted that large applicants are over-weighted due to their large numbers of applications. Contact details were successfully established for 1,524 applicants and 772 responses were returned (leading to a response rate of 51% of contacted applicants, or 37% of the initial sample). The survey was carried out via telephone and mail interviews with the pre-established contact persons in English, French, German and Japanese.[4]

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

Table 1 shows the technological areas of firms in the sample as well as the median number of priority filings (PF) in 2005. Note that, throughout the paper, the term 'industry' is preferred over 'technological area' (or 'joint cluster' in EPO's jargon) for the sake of simplicity. The first subsample (SMEs) is composed of 94 private companies with less than 250 employees. The second subsample comprises 298 large companies and is used as a control group to highlight differences in behaviour between SMEs and large companies.[5] In the first (second) sample, 57% (54%) of the companies are based in Europe and 18% (15%) come from the U.S. Other countries include, but are not limited to, Australia, Israel or Japan.

Table 1. Industry composition of the samples of SMEs and large companies.

Industry	n		Median PF in 2005	
	SMEs	Large	SMEs	Large
Audio, video, media	3	5	2	1060
Biotechnology	10	5	6	6
Civil engineering; thermodynamics	6	13	3	71
Computers	1	2	0	630
Electricity and semiconductors	8	19	6	113
Electronics	3	10	2	232.5
Handling and processing	9	18	2	14
Human necessities (incl. medical products)	12	31	3.5	71
Industrial chemistry	6	18	3.5	72.5
Measuring and optics	3	13	2	134
Polymers	3	7	3	673
Organic chemistry (incl. pharmaceuticals)	2	12	1.5	170
Telecommunications	0	10	-	395
Vehicles and general technology	5	28	4	101.5

Notes: 'PF' stands for priority filing. A company belongs to a given industry (joint cluster) if it spends the highest amount of R&D in this industry. If a company spends an equal amount of R&D dollars in more than one industry, it is assumed to belong to all the industries

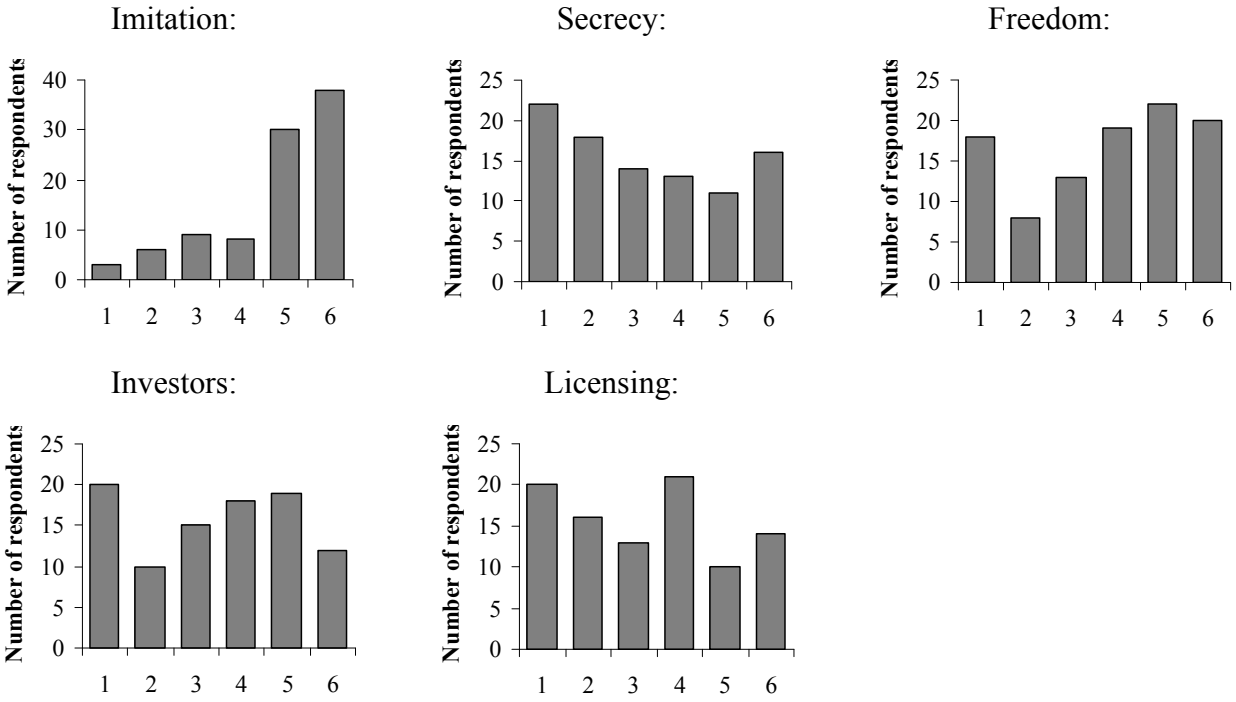
The SMEs in our sample had a median number of three priority patent applications in 2005 whereas large companies had a median number of 44 patents. A few SMEs have a high number of patents, such that the median number of patents for SMEs considerably differs from the mean (about 20 PF). It is important to keep in mind that the SMEs included in this analysis form a highly selective group among SMEs as a whole – not every SME can afford to patent at the EPO.

3.1 Motivations to patent

Respondents were asked to rate a series of assertions between 1 (completely disagree) and 6 (fully agree) related to their motivations to use the patent system. Figure 1 provides the distribution of answers for five motivators: 'Imitation' (I patent mainly to prevent imitation by competitors); 'Secrecy' (I will not patent an invention that I can keep secret); 'Freedom' (I patent mainly to protect my freedom of operation); 'Investors' (I take patents in order to convince investors or banks of the value of my invention); and 'Licensing' (I take patents in view of licensing).

[5] The drop in sample size from 772 applicants to 392 applicants (94 SMEs + 298 large companies) comes from missing information on key variables. See Appendix A for more details.

Figure 1. Overview of SMEs' motivations to patent.



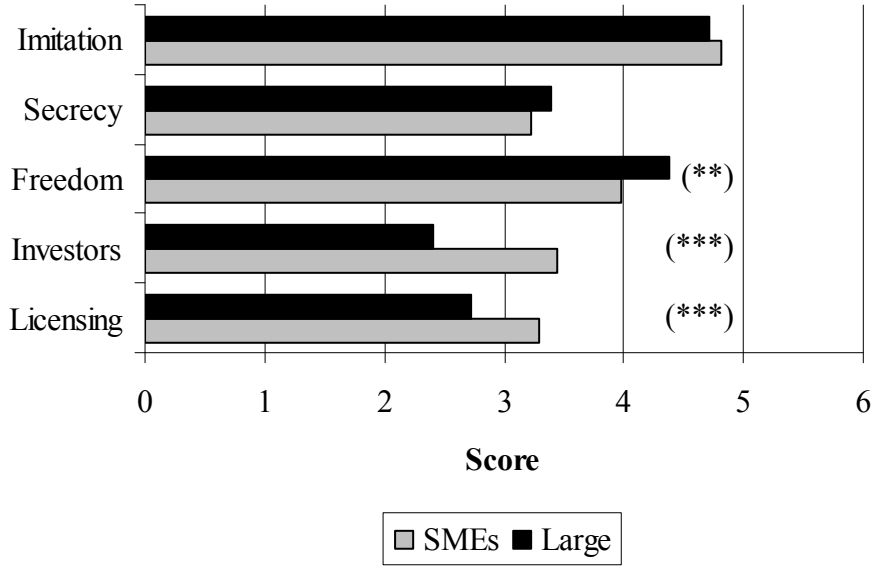
Notes: The x-axis is the Likert score (from 1 = completely disagree to 6 = fully agree). See main text for the exact wording of the motives.

The distribution of the variable 'Imitation' is highly skewed to the right: a large majority of SMEs file patents to protect against imitation by competitors. The 'freedom' motivation is the second most important reason to patent, with a mean score of around 4. The 'investors' and the 'licensing' motives come third and fourth, respectively, with a mean score of around 3.5. It is very difficult to interpret these figures since no benchmark is available. A comparison with large companies is provided in Figure 2, which reports the mean scores of answers for SMEs and large companies.

Large companies mainly file patents to prevent imitation and to protect their freedom of operation. The scores for the monetary motivations ('Investors' and 'Licensing'), which are above 3 for SMEs, are significantly lower for large companies. A closer look at the data (not reported) suggests that more than 40% of the SMEs have strong monetary motivations (i.e. they score 5 or 6 on the 'Licensing' or the 'Investors' motives), and there is evidence that monetary motivations for these firms are at least as important as the protection against imitation. By contrast, this figure is only about 15% for large companies. The share of SMEs engaging in patenting for financial reasons is thus considerably higher than the respective share of large firms. Note that the high score of the 'Imitation' motive is not surprising: a prerequisite for a patent to be a credible signal to investors is that it confers a good protection against imitation.

Table 2 reports the correlation between motives in order to understand how they relate to each other. The lower (upper) triangular part of the matrix reports the correlation coefficient for SMEs (large companies).

Figure 2. Motivations by type of company.



Notes: Answers are Likert items from 1 (fully disagree) to 6 (fully agree). See main text for the exact definition of the labels. ***, ** and * indicate significance at 1%, 5% and 10% of the Mann-Whitney rank sum test for the difference in means between the sample of SMEs and that of large companies.

Table 2. Correlation of answers for SMEs (*under the diagonal*) and large companies (above the diagonal).

	Imitation	Secrecy	Freedom	Investors	Licensing
Imitation	-	0.07	0.12 **	-0.03	-0.08
Secrecy	*0.08*	-	0.05	-0.06	-0.13 **
Freedom	*0.06*	*0.06*	-	0.05	-0.02
Investors	*-0.11*	*-0.18* *	*0.17*	-	0.45 ***
Licensing	*-0.18* *	*0.04*	*0.25* **	*0.41* ***	-

Notes: partial correlation coefficients controlling for country effects. ***, ** and * indicate significance at 1%, 5% and 10% of the likelihood ratio test of no correlation.

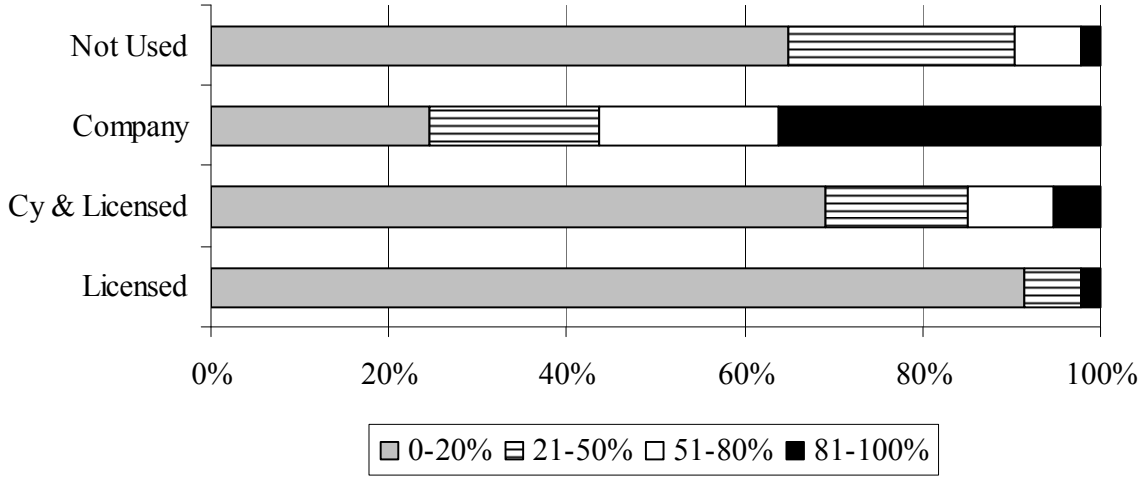
The negative correlation coefficient between the 'Investors' and 'Secrecy' motivators is very revealing. Companies that want to convince investors will patent their invention even if they could have kept it secret – particularly SMEs. In other words, it suggests that companies believe that patents are a credible signal as they are willing to disclose extra information – and bear patenting costs – to attract investors. The most correlated motives are the investors and the licensing motives, for both SMEs and large companies: companies that tend to take patents in order to convince investors will also be more likely to take patents in view of licensing them out. This finding legitimates the term 'monetary patent' put forward in this paper.

3.2. Use of patent portfolio

Additional key information gathered is related to how companies use their patent portfolio. Respondents were explicitly asked to indicate the percentage of their patent portfolio that is not used (N), exploited in the company only (C), exploited in-house and licensed to other

companies (CL), and licensed only to other companies (L).[6] They were given boxes to tick with predetermined ranges of percentage. Figure 3 indicates the distribution of SMEs that fall into each category.

Figure 3. Use of patent portfolio by SMEs.



Notes: The figure reports the proportion of SMEs that fall into each range of intensity (0-20%, 21-50%, 51-80%, 81-100%), for each type of use.

It appears that most of the SMEs use their patent portfolio quite actively. Indeed, around 65% of the companies reported that 0 to 20% of their portfolio is not used (which means that 65% of the companies use between 80 and 100% of their patents). The majority of patents seem to be used internally as indicated by the variable 'Company.' Around a third of the companies have at least 20% of their portfolio that is used internally and licensed (variable 'Cy & Licensed') and a tenth have at least 20% of their portfolio that is exclusively licensed.

Table 3 presents a comparison of how SMEs and large companies use their patent portfolio. The SMEs are further separated into European and U.S. companies to highlight potential regional differences.

Table 3. Mean score, use of patent portfolio.

	EU SMEs *n = 54* (1)	EU Large *n = 161* (2)		U.S. SMEs *n = 17* (3)	
Not used (N)	1.46	2.04	***	1.41	-
Company only (C)	2.70	2.60	-	2.82	-
Company and licensed (CL)	1.39	1.19	**	2.06	**
Licensed only (L)	1.09	1.02	*	1.35	**

Notes: the uses are rated on an ordinal variable (1:0–20%; 2:21–50%; 3:51–80%; 4:81–100%). The second column of 'EU Large' and 'U.S. SMEs' reports the significance level for the Mann-Whitney rank sum test for difference in means with 'EU SMEs'. ***, ** and * indicate significance at 1%, 5% and 10% probability threshold, respectively. For clarity, the analysis is performed for EU firms and U.S. SMEs only (232 firms). Large U.S. companies and other foreign companies are excluded (160 firms).

[6] The patent portfolio is defined in the survey as the number of patents filed in 2000–2005 that were still valid at the time of the survey (2006).

Small and medium companies tend to use their patents more than large companies, as indicated in the first row of Table 3. Two possible explanations can be put forward. First, patents are expensive and SMEs will presumably be very selective when deciding if patent protection must be applied for. Graham et al. (2009), for instance, find that cost considerations loom large for high-technology start-ups in deciding to forego patenting. In a similar vein, de Rassenfosse and van Pottelsberghe de la Potterie (2007, 2011) estimate the price elasticity of demand for patents to be lie between -0.30 and -0.50. Given that SMEs are less wealthy than large companies, one can expect the price elasticity to be significantly higher for small companies. Second, large companies apply for freedom to operate motives to a greater extent than small companies (see Figure 2) which might also explain why more of their patents are 'sleeping' and not used actively. Regarding the share of the portfolio licensed, SMEs have a higher share of the portfolio licensed than large companies, as shown in column (2). However, we also find that U.S. SMEs significantly outperform European companies in terms of licensing rate (see column (3)). The difference could potentially be explained by a higher willingness to license or by a better functioning of the U.S. market for technology, or both. This question will be investigated in the empirical analysis.

4. Empirical analysis

The objective of the econometric analysis is to understand the determinants of the use of the patent portfolio. In particular, we would like to understand how the motivations to patent affect the use of patents and investigate potential regional and size differences.

Each use (N, C, CL, L) is an ordinal variable that can take any of the four values associated with the corresponding range of intensity (0-20%, 21-50%, 51-80%, 81-100%). The variable 'Licensed (L)', however, is highly skewed to the left (96% of the companies are in the range 0 to 20%). As a result, we computed a new variable L* = (CL + L)/2 rounded to the next largest integer. L* takes the values 1, 2, 3 and 4 indicating how much of the patent portfolio is licensed (regardless of whether the patents are also used internally). We thus have three dependent ordinal variables Y_1 (=N), Y_2 (=C) and Y_3 (=L*). A natural way of explaining the score for each use is to estimate ordered probit models, where the odds of falling into each range of intensity change as a function of some explanatory variables. Formally we define for the first dependent variable (Y_1) and the *i*-th individual:

$$y^*_{1,i} = x_i^{'}\beta_1 + \varepsilon_{1,i}, \tag{1}$$

where $y^*_{1,i}$ is the exact but unobserved proportion of the portfolio that is not used; x_i is the vector of independent variables, β_1 is the vector of regression coefficients and $\varepsilon_{1,i}$ is ~ N(0,1). We observe the limited dependent variable $y_{1,i} = j$ if $\gamma_{j-1} < y^*_{1,i} \leq \gamma_j$ that is, if the latent variable $y^*_{1,i}$ falls between the two threshold values γ_{j-1} and γ_j (to be estimated, jointly with the β's).

We have for, say, $j = 2$:

$$P(y_{1,i} = 2 \mid \mathrm{x_i}) = P(\gamma_1 < y^*_{1,i} \leq \gamma_2) = \Phi(\gamma_2 - x_i^{'}\beta_1) - \Phi(\gamma_1 - x_i^{'}\beta_1), \tag{2}$$

where $\Phi(\cdot)$ is the cumulative normal distribution function. It would be too simplistic to treat the system $\{Y_1, Y_2, Y_3\}$ as a system of independent equations. Since the variables represent alternative uses of the patent portfolio, an increase in one of the variables necessarily reduces the score of the other variables. We take this dependency into account by modelling the joint distribution for the errors $\varepsilon_1, \varepsilon_2, \varepsilon_3$:

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \end{pmatrix} = N\left[\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{pmatrix}\right], \tag{3}$$

where we expect the errors to be negatively correlated with each other. Formally, we thus estimate the determinants of the use of the patent portfolio using a trivariate ordered probit regression, which takes into account the dependence between the three alternative uses of the portfolio (N, C, L*). The estimations are performed with the user-written Stata command 'gmk' (Roodman 2009).

The set of explanatory variables (x) that are used includes: i) the five motives to patent; ii) the geographic origin of the firm; iii) a dummy variable for SMEs; and iv) the size of the patent portfolio as captured with the number of priority filings applied for in 2005 ('PF').[7] The 14 industry dummies (joint clusters) were also included in the regression but are not reported. The results are presented in Table 4.

Note that the parameters of a probit model are not straightforward to interpret. This is particularly true with ordered probit models, as the marginal effect of changes in the regressors must be computed for each outcome. For this reason, we directly report the estimation of the β's (equation 1); larger values thus correspond to a higher outcome. We provide a detailed analysis of changes in predicted probabilities for one variable of interest at the end of the section.

Five results are particularly worth commenting on. Firstly, SMEs are more likely to exploit their patents more intensively than large firms. Controlling for the number of PF, being an SME increases the probability of using a higher share of the patent portfolio – more correctly, decreases the probability that a higher share of the portfolio is not used – as indicated in column (1). Patents are expensive and SMEs will presumably be very selective when deciding if patent protection must be applied for. The effect is particularly strong in the U.S., where companies are significantly less likely to have a higher share of the portfolio that is not used as compared with European companies.

Secondly, companies that patent in order to protect their freedom to operate are more likely to have a higher proportion of their patent portfolio that is not used (see column (1)). Such patents aim at building prior art and do not necessarily result in commercial exploitation.

[7] The attentive reader will have noticed that the dependent variables relate to the patents filed over the period 2000 to 2005 while the regression controls for the size of the patent portfolio with the number of patents filed in 2005. This is due to the fact that we have no information on earlier patent filings – we have to take the data as it is.

Table 4. Determinants of the use of patent portfolio.

	(1) N	(2) C	(3) L*	(4) C	(5) N	(6) L*
PF	0.05	-0.17 ***	0.14 **	-0.16 ***	0.05	0.12 ***
	(0.04)	(0.03)	(0.07)	(0.03)	(0.04)	(0.04)
SMEs	-0.65 ***	0.07	0.40 ***	0.27 ***	-0.85 ***	
	(0.02)	(0.05)	(0.04)	(0.03)	(0.13)	
US	-0.25 ***	0.08	0.91 ***	0.07	-0.25 ***	
	(0.06)	(0.07)	(0.18)	(0.07)	(0.06)	
EU27	0.19 *	-0.09	0.19 **	-0.09	0.19 *	
	(0.11)	(0.10)	(0.09)	(0.10)	(0.11)	
IMITATION	0.07 **	0.04 ***	0.00	0.04 ***	0.08 **	-0.01
	(0.03)	(0.00)	(0.01)	(0.00)	(0.03)	(0.02)
SECRECY	0.01	-0.02	-0.04 ***	-0.02	0.01	-0.04 ***
	(0.03)	(0.03)	(0.00)	(0.03)	(0.02)	(0.00)
FREEDOM	0.04 **	-0.02	0.01	-0.02	0.04 **	0.00
	(0.02)	(0.06)	(0.05)	(0.06)	(0.01)	(0.05)
INVESTORS (INV)	-0.03 ***	0.12 ***	-0.05 ***		-0.03 ***	-0.05
	(0.01)	(0.01)	(0.02)			(0.03)
LICENSING (LIC)	0.08 ***	-0.23 ***	0.33 ***	-0.23 ***		0.33 ***
	(0.02)	(0.03)	(0.01)	(0.03)		(0.01)
INV*SME				0.07 ***		
				(0.00)		
INV*LARGE				0.14 ***		
				(0.02)		
LIC*SME					0.12 ***	
					(0.03)	
LIC*LARGE					0.06 ***	
					(0.01)	
US*SME						1.40 ***
						(0.02)
EU*SME						0.45 ***
						(0.07)
US*LARGE						0.74 ***
						(0.09)
EU*LARGE						0.10 ***
						(0.03)
Polyserial R^2	0.28	0.15	0.30	0.15	0.28	0.29

Notes: The econometric regression is trivariate ordered probit. The variable 'PF' controls for the number of priority filings in 2005. The sample contains 392 firms (SMEs and large companies). Polyserial R^2 is the square of the polyserial correlation coefficient between the dependent variable and its predicted value. Industry dummies (joint clusters) were included but are not reported. Robust standard errors reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% probability threshold, respectively.

Third, the negative coefficient associated with the 'Investors' motivation in column (1) – and the positive coefficient in column (2) – indicates that a higher reliance on investors increases the proportion of patents that is used. However, the results presented in column (4), in which the effect of the investor motivation is broken down by type of company, suggest that this interpretation is especially true for large companies. It may be due to the fact that SMEs that take patents to access the capital market may not have found the necessary resources to exploit their inventions.

Fourth, controlling for the number of PF, SMEs as a whole are more likely than large companies to have a larger share of their patents licensed, as shown in column (3). There is also a positive and significant impact of the licensing motivation on the share of patents that are licensed. This result is not surprising but makes clear that licensing deals are supply-driven rather than demand-driven. The results presented in column (5) somewhat temper the interpretation. The willingness to license also leads to a higher proportion of patents that are left unused, especially for SMEs, probably due to the difficulty in finding potential licensees. The greater licensing rate in the U.S. must also be mentioned (column (3)). Controlling for the willingness to license, being based in the U.S. increases the chances that a high proportion of the patent portfolio is licensed. This U.S. effect holds for SMEs and large corporations as indicated in column (6). Given that the regression controls for the willingness to license, the poorer licensing rates of European companies seem thus to be explained by structural factors: either by a greater development of the U.S. market for technology or by inefficiencies in the European market. In this respect, Gambardella et al. (2007) provide evidence that transaction costs in the European market for technology prevent licensing agreements from being concluded.

Finally, it is worth noting that although the 'Investors' and the 'Licensing' motivations are highly correlated (see Table 2) they have a clear opposite effect on the use of the patent portfolio. This result underlines the two distinct strategies associated with these motivations (internal use versus external use of the technology).

Note that the variance-covariance matrix of the errors (equation 3) suggests, as expected, that the error terms are negatively correlated with each other (ρ_{12} = -0.45, ρ_{13} = -0.07, ρ_{23} = -0.17 for the baseline model in columns (1)-(3) of Table 4).

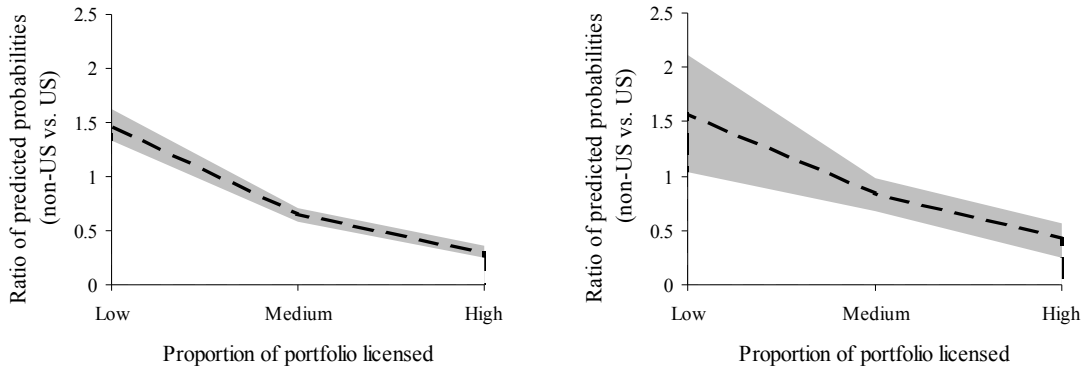
It could be argued that the results are partly driven by the sample composition, in particular as far as the U.S. effect on the rate of licensing is concerned. Since the data has been collected by the EPO, the sample includes European companies active in the EU and non-European companies active in the EU. The foreign companies included in the sample might thus be more 'international' than the average European company, which could explain the important U.S. effect on the share of the portfolio licensed. Appendix A presents evidence that the European firms in the sample are as international as the foreign firms. The reason is simple: the EPO being a regional office, SMEs with no international ambition would simply file in their national office. The regressions presented in Table 4 were also estimated on a subsample that excludes the least international European companies (i.e., companies that did not file patents at the United States Patent and Trademark Office, the Japan Patent Office or via the PCT route) and a similar effect was observed (not reported).

Other robustness tests were performed but are not reported. First, the number of PF was taken to the log to control for potential outliers (some companies have a portfolio size that far exceeds the mean size) and similar results were obtained. The regressions were also performed without controlling for the motivations to patent to capture the global U.S. effect on the licensing rate. Interestingly, the parameter associated with the U.S. dummy only slightly changed. This is due to the fact that the motivations to patent do not differ much between Europe and the U.S.

The U.S. effect on the licensing rate is illustrated in Figure 4, which plots the ratio of predicted probabilities of having a low, medium or high share of the patent portfolio licensed for non-U.S. versus U.S. SMEs. The left-hand side of Figure 4 plots the ratio of probabilities

computed from the estimation of a regression model that does not control for the motivations to patent (in order to capture the global U.S. effect on the rate of licensing). For instance, the predicted probability that the ordinal variable 'Licensed (L*)' is equal to 1 (i.e. a low share of the patent portfolio is licensed) is equal to 0.71 for non-U.S. SMEs and 0.48 for U.S. SMEs. In other words, a U.S. company has a 48% chance of having a low share of its patent portfolio licensed. The ratio of predicted probabilities is therefore equal to 1.48 (0.71/0.48), which indicates that non-U.S. companies are 1.48 times more likely to have a low share of their portfolio licensed as compared to U.S. companies (see left-hand side of Figure 4). Both groups have equal chances when the ratio is not significantly different from 1. The right-hand side of Figure 4 is based on the results presented in column (3) of Table 4; they control for the motivations to patent. The ratio of probabilities are computed for SMEs willing to license (i.e., which have a score greater than or equal to 4 on the 'Licensing' motivation).

Figure 4. Ratio of predicted probabilities of having a low, medium or high share of the patent portfolio that is licensed (non-U.S. versus US) for all SMEs (left) and the sample of SMEs willing to license (right).



Notes: the ratios in the left-hand side have been computed from a regression model that does not control for the motivations to patent whereas the ratios in the right-hand side are based on the results presented in column (3) of Table 4. They indicate the probability that a non-U.S. company has a low, medium or high share of its patent portfolio licensed as compared to a U.S. company. The grey areas represent the 95% confidence interval.

Non-U.S. SMEs are around 2/3 times (0.25/0.38) as likely as U.S. SMEs to have a medium share of their portfolio licensed (or, alternatively, U.S. companies are 1.5 times more likely than non-U.S. SMEs to have a medium share of their portfolio that is licensed). It is 3.5 times more likely that U.S. SMEs have a high licensed share compared with non-U.S. SMEs. The picture looks slightly different if the ratios are computed for SMEs willing to license (depicted on the right-hand side of Figure 4), but non-U.S. SMEs are still 2 times less likely to have a high share of their portfolio licensed. The figure therefore illustrates the dramatic impact of the imperfections of the market(s) for technology in Europe that, clearly, hinder the monetary use of patents.

5. Concluding thoughts

We have explained how SMEs can take advantage of their patents to mitigate the problems associated with the financing of R&D. Innovative companies face a high cost of capital that limits the level and breadth of their R&D investments. The problem is particularly acute for SMEs that usually lack internal resources and have difficulties in accessing external capital. In this respect, taking patents for monetary reasons can mitigate the difficulties encountered

by these firms through three channels. First, early patent protection can be used as a signal to reduce information asymmetry. Second, patents can also be used as collateral to secure funding, and third, the licensing of patents generates additional cash flows that can further be used to finance innovation. We have introduced the term 'monetary patents' to refer to patents that are taken in view of convincing investors or generating licensing revenues.

The empirical analysis is based on data from an international survey conducted by the EPO. It has allowed us to assess the popularity of monetary patents and to understand how various motivations to patent affect the use of the patent portfolio. Comparing the motivations to patent across sizes of companies, we have highlighted that SMEs and large companies use the patent system differently. While SMEs mainly patent to protect from imitation, nearly half of them also patent for monetary reasons. Large companies mainly patent to prevent imitation by competitors and to protect their freedom to operate. Looking at how the patent portfolio is used, we find that SMEs use their patents more than large firms do, both in Europe and in the U.S. Patents are expensive and SMEs are probably more selective when deciding if patent protection must be applied for. In addition, large companies often file patent applications to secure freedom to operate, which results in a larger proportion of patents that are not used. The estimation of trivariate ordered probit regression models of the determinants of the use of the patent portfolio leads to the conclusion that companies that take patents to convince investors have a lower share of their patent portfolio that is not used and use their patents more internally. However, the effect is weaker for SMEs, which may suggest that some SMEs face difficulties in finding the necessary resources to exploit their inventions. Regarding the licensing of patents, SMEs have a higher share of their patents that are licensed than large companies, but companies in the U.S. severely outperform those in Europe. Controlling for the willingness to license and the size of the patent portfolio, the share of patents licensed for European SMEs still remains significantly lower than U.S. SMEs. A U.S. company that is willing to license is twice more likely to have a high share of its portfolio that is actually licensed as compared to a non-U.S. company willing to license. This result suggests inefficiencies in the European market for technology.

Ortega-Argilés et al. (2009) propose several kinds of public intervention to support R&D activities in SMEs. The results presented in this paper call for two additional policy recommendations that aim at strengthening the monetary role of patents for SMEs. First, the European market for technology needs to be further developed in order to ease transactions. It is beyond the scope of this article to tackle the potential failures of the market for technology, but a better functioning market would make patents a better tradable good, which would both facilitate their use as collateral and make it easier to find potential licensees. The creation of the community patent would be a major improvement in this respect (van Pottelsberghe de la Potterie 2009). Similarly, the development of specialized IP agents and entities focusing on patent-related transactions would decrease transaction costs (see Yanagisawa and Guellec 2009, for a comprehensive analysis of IP specialist firms). Second, it is particularly important that patent offices 'raise the bar' on patent quality in order to reinforce the credibility of the signal embedded in patents. In the current context of historically high backlogs, it is tempting for patent offices to focus on the quantity of patents examined at the expense of quality. However, credible signalling can only happen if offices guarantee a high enough level of quality of the examination. The more informative the signal, the more confident the investors and the more the information asymmetry is reduced.

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Appendix A. Composition of sample: methodology and potential biases

There are 772 observations in the initial dataset but the working sample is limited to 392 applicants (94 SMEs + 298 large companies). The reduction in the number of observations comes from various missing data. Information on the use of the patent portfolio is missing for 331 applicants. Among the 441 remaining observations, information on the motivations to patent is missing for 9 firms and 14 firms did not report the number of priority filings (PF) in 2005. Among the 418 applicants that remain, we excluded 26 applicants that are non-private entities (such as government laboratories or universities). We obtain a total of 392 firms.

One can test whether the missing information results in a selection bias in terms of company size and geographic origin. The number of PF in 2005 is observed for a majority of applicants (744 out of 772) and we have information on the geographic origin of all the applicants. Approximately 50% of the applicants in the initial sample come from the EU-27, 23% come from the U.S. and 14% come from Japan. The remaining 13% come from countries as diverse as Australia, Canada or Israel.

We can thus estimate whether these two parameters influence the probability to be included in the final sample. Table A1 presents the result of a probit regression where the dependent variable takes the value of 1 if the firm is included in the sample and 0 otherwise.

Table A1. Likelihood to be included in the final sample (probit estimation).

	(1)
Priority filings (1000)	-0.10*
	(0.06)
US	-0.39**
	(0.16)
EU	0.17
	(0.15)
JP	0.45**
	(0.19)
Pseudo R^2	0.03
Observations	744

It seems that large applicants have a higher tendency to skip some parts of the questionnaire, as well as foreign applicants (both U.S. and Japanese applicants). Note that if the estimation is performed on the subsample of private applicants only, then the dummy for Japanese applicants becomes not significant (not reported).

The mean number of PF in the final sample is of 203.47 whereas it is of 311.24 for these observations that were excluded from the final sample. However, the variance is quite high and the difference in means is not statistically different from zero (p-value of a two-sided t-test of 0.19). The median number of patents in the final sample is 28.5 and the median number of patents from applicants that were excluded from the sample is 23.5 such that we should not be worried too much by this selection bias. Although the focus of the present paper is on SMEs, it is important to keep in mind that some very large applicants did skip some parts of the questionnaire.

Another important issue that must be dealt with concerns the potential difference that may exist between European SMEs and non-European SMEs. Since the initial population is composed of firms having filed at least one patent application at the EPO, the analysis looks at non-European firms active in the EU as opposed to European firms active in the EU.

Yet, the difference between European and non-European SMEs may not be as strong as expected. Since the EPO is a regional office, European firms that apply for a patent at the EPO are already international to some extent (otherwise they would simply file patents at their national office – the national route being cheaper, faster, and easier).

A first way to assess the comparability between European and foreign companies consists in testing whether the mean family size (FS, the ratio of second filings to PF) significantly differs between these two groups. Table A2 presents the result of a two-sided mean comparison test. The mean family size between European and non-European SMEs is not significantly different from zero, suggesting that the European SMEs are comparable to the group of foreign SMEs in this respect.

Table A2. Mean comparison tests

	All companies		SMEs only	
	EU	non-EU	EU	non-EU
Mean FS	1.59	1.31	1.27	1.44
Observations	213	173	53	38
p-value	0.30		0.70	

Notes: 'FS' stands for 'family size'. It is defined as the ratio of the number of second filings in 2005 and 2006 over the number of PF in 2005 and 2006. 6 firms that had missing information on the second filings were excluded from the sample.

The mean family size may not necessarily reflect the extent of the internationalization of companies. There is admittedly a difference between a German SME that files a patent in Austria as opposed to a U.S. SME that files a patent in Austria. A closer look at the geographic destination of the patents in European firms' portfolios suggests that around 80% (42 out of 54) of the European SMEs have filed at least one patent application at the USPTO, JPO or via the PCT route. Although this number is reassuring, the regressions in main Table 4 will also be estimated by excluding the European companies that did not file any patent applications at the USPTO, JPO or via the PCT route.