THE IMPACT OF THE PATENT SYSTEM ON SMEs

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Abstract
The authors consider the theory and evidence on the propensity of small and medium-sized enterprises (SMEs) to patent their innovations. Drawing on UK, European and US literature and data sources, they show that small firms are less likely to use patents as a means of protecting their investment than other means such as confidentiality, secrecy or time to market. SMEs are also less likely than larger firms to use others' patents as a source of information for their own innovation activities, preferring customers, suppliers and trade fairs. Conversely, smaller firms are more likely than larger firms to put their patents to productive use or to licence out their technology, a pattern that is likely to reflect relatively higher cost and capacity pressures. Among the emerging trends, of particular interest for high tech SMEs is the role of patents as an increasingly important factor in obtaining financial backing by venture capitalists. A survey of UK and US small businesses conducted jointly by the Centre for Business Research (CBR) at Cambridge and the Industrial Performance Unit at the Massachusetts Institute of Technology provides data for further analyses which reveal that small firms in the United States are twice as likely as those in the UK to patent innovations, but are still much less likely to patent than larger US firms. The authors conclude with a general discussion of main findings from a UK and European perspective.

Keywords: Patents; SMEs; innovation; intellectual property

JEL classification: D23, L20, O34

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1.Introduction

In this paper, we review the conceptual arguments for believing that patents and the patent system may have a role to play in the performance of SMEs in the economic system. We review both the conceptual background to, and the empirical evidence for, the impact of patents on SME behaviour in Europe and the UK. We refer, where appropriate, to evidence from other countries, but our emphasis is essentially within the European domain, with a particular emphasis on the UK.

A number of arguments have been put forward for believing that the role of SMEs in innovation and hence the impact of the patent system upon them is of particular importance. First, SMEs are claimed to be central to Schumpeterian processes of "creative destruction". There are two components to this argument. First, it is argued that small and medium sized enterprises are active innovators, particularly in products of a more radical nature that can threaten the dominant position of existing large firms. In this sense, SMEs should have the greater potential to induce structural change and disrupt the position of incumbent, dominant firms with ultimate benefits to the consumer. Second and relatedly, it is argued that they are more efficient users of resources in the process of innovation. Whilst there is some evidence to suggest that SMEs may be more efficient innovators than large firms in the sense of generating higher levels of innovative activity for a given level of R&D input, it is also the case that the translation of innovations into substantial competitive advantage may pose problems for smaller businesses. The translation of innovation into large-scale commercially viable business appears to require the superior ability of large firms to appropriate the returns to innovation and execute the transition from original invention and niche market into large market domination. In this sense on average SMEs appear to lag considerably behind larger firms. To the extent that this is a result of the superior ability of large firms to appropriate the value from their innovative activity due to patenting, this would suggest that property rights may be an important factor to consider in distinguishing, in terms of innovation potential, large from small firms.

In this connection, a number of arguments become important. First, SMEs reliance on patents as a source of competitive advantage may be hindered by costs that either on average or at the margin are higher than those for large firms. Secondly, the ability to recognise and develop an efficient level of protection through patenting may be hindered in SMEs because they do not have sufficient internal competence to manage effectively this aspect of their business development. Finally, it may be argued that even where SMEs are able to recognise the importance of patenting and to put in place appropriate patents, they may be at a substantial disadvantage in enforcing their IP rights. This is

particularly likely to be the case with respect to larger firms who not only may have a sufficiently deep pocket to protect their own IP or challenge the IP of SMEs, but may have greater competence at both designing and defending their own patent position against emergent rival patents. Although the mainstream economic rationale is broadly accepted, a number of firm-specific and sector-dependent factors make the role of strong IP through patents and its effects on the strategy and performance of SMEs rather controversial.

This paper defines SMEs relative to larger firms. It is structured as follow. Firstly, we discuss the role of SMEs as innovators. Secondly, we address the rationales for strong IPs and their drawback. We then address the question of the extent to which SMEs use patents as means to protect intellectual property rights as opposed to, or in combination with, other forms of IP protection. We report the main findings from the literature but also provide some statistics on the patenting behaviour of UK SMEs drawn from the UK Community Innovation Survey data. These are supplemented by findings from an original benchmarking survey of UK and US small businesses. In examining the trends that emerge from empirical analysis, we finally discuss where the relation between the patent systems and SMEs works and where, instead, it does not perform to stimulate innovation and/or enhance the prospects of its private and social returns.

2. SMEs as innovators: the UK evidence

It is conventional to define SMEs in terms of employment size and most recently in EU OECD and other statistics to define SMEs as businesses employing less than 250 employees. Defined in this way, however, the small and medium-sized enterprise (SME) sector still covers a very wide range of firms. Discussions of the role of intellectual property in relation to SMEs therefore needs to be conducted with a clear grasp of the relative importance of different sizes and types of SMEs and their role in innovation, and R&D, as well as the various ways in which the value from innovation activity may be appropriated. In this section we first of all provide a brief overview of the range of firms' sizes and growth patterns within the SME sector, and their relative importance by industry. We then turn to a discussion of their role in R&D and their comparative rates of innovation activity.

In numerical terms it is clear from Table 1 that small and medium-sized enterprises are a significant part of the economy. If we begin by defining SMEs as those businesses employing less than 250 people, then we find there were 4.7 million such businesses in 2008. Within that group, however, 3.5 million had no employees. Taken together, these latter businesses, run as sole proprietorships or owned by individuals otherwise working on their own behalf, accounted for

around 17% of UK employment, but a much lower proportion (8%) of turnover. Shifting a little further up the size scale SMEs employing 1-9 people employed a further 1 million workers, mainly accounted for by businesses employing between 1 and 5 people.

Table 1. Number of enterprises, employment and turnover by number of employees, UK private sector, start of 2008

	Number		
	Enterprises (/000s)	Employment (/000s)	Turnover[1] (/£million)
All enterprises	4,783	23,128	2,994,978
All employers	1,238	19,239	2,763,280
With no employees[2]	3,546	3,888	231,698
1-9	1,033	3,857	420,282
10-49	172	3,332	442,396
50-249	27	2,665	406,450
250 or more	6	9,386	1,494,152

[1] "All Industries" turnover figures exclude Section J (financial intermediation) where turnover is not available on a comparable basis.

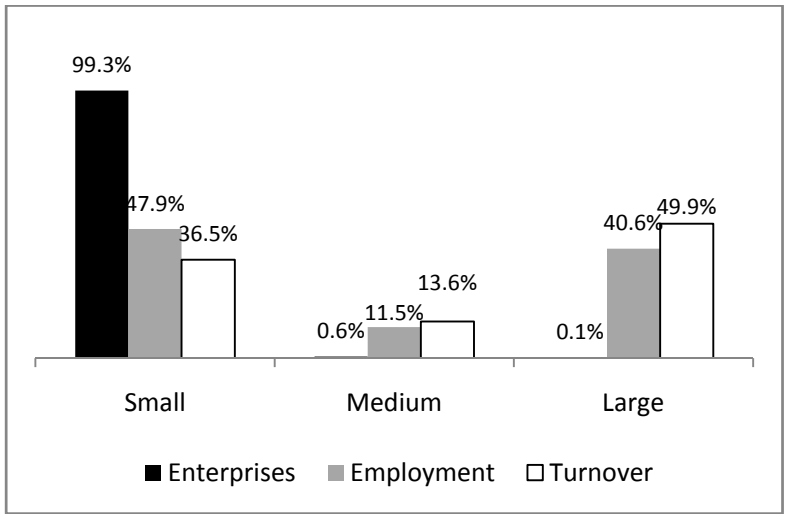
[2] "With no employees" comprises sole proprietorships and partnerships comprising only the self-employed owner-manager(s), and companies comprising only an employee director.

There are only around 170,000 firms employing between 10 and 249 workers. In contrast, there were only 6,000 businesses that employed 250 workers or more. These, however, as Figure 1 shows accounted for 49% of all turnover and 41% of employment. These 6,000 businesses accounted for almost as much employment as, and more turnover than the 1.2 million businesses shown in Table 1 who employed between 1 and 250 workers, and more turnover than the 4.5 million enterprises employ employing between 0 and 49 people shown in the first bars of Figure 1.

It is also useful to consider the distribution of small and medium-sized enterprises by sector. The proportions of small businesses are highest in the agricultural sector, in construction, hotels, health and personnel services and business services activities. They are relatively low in manufacturing and the financial sector (BIS, 2009). In our analysis of the use of intellectual property protection, we are therefore careful to disaggregate by sector.

In addition to the skewness in size distributions, there is also an extreme skewness in growth rate performance. If we focus on SMEs employing between 10 and 250 employees in the UK in the periods 2002-5 and 2005-8, we can define high growth firms as those which in any period of three years achieved an annualised growth rate of employment or turnover of 20%. On this basis only between 5% and 6% of UK SMEs meet the criteria in employment growth terms and between 9% and 13% of UK SMEs do so in turnover growth terms (Anyadike-Danes et al., 2009).

Figure 1. Share of enterprises, employment and turnover by size of enterprise UK private sector, start of 2008.



Note: Small=0-49 Medium=50-249 Large=250 and over

The share of these high growth firms is greater amongst younger (under 5 years old) than older (5 or more years old) firms, but there are far more older firms in the UK economy, so it is fast growth amongst these that has the greatest turnover and employment impact (Anyadike-Danes et al, 2009). It is important to note that these fast growing SMEs are to be found in all sectors of the economy and only a small minority are in high technology manufacturing activities. For instance, in the time periods discussed above business services, wholesale and retail firms provide over half the high growth firms whilst manufacturing accounts for only 1 in 10 (Anyadike-Danes et al., 2009).

We now turn to the role of SMEs in innovation activity in broad terms. One way to look at this is to consider the amount of R&D done by businesses of different sizes. The UK data on R&D also allow a distinction to be made between the R&D undertaken by independent SMEs with less than 250 employees and to compare that with R&D activity in the business sector in total. In 2005 total UK business enterprise research and development expenditure as a whole was a

little over £13 billion. In that year, independent SMEs employing less than 250 workers spent only £454 million on R&D activity. This is 3.3% of total UK business enterprise R&D expenditure. In 2006, moreover, R&D expenditure by SMEs fell somewhat to £356 million (ONS, 2008, Table 26). Even if these figures are measured with a substantial degree of error, they point to the relatively small amount of R&D undertaken by independent SMEs. Insofar as it is businesses who are conducting this kind of research and development activity who might have most need of an efficiently working intellectual property sector, it is important to bear in mind the relatively small amount of activity which is covered. This is not to deny that there may be important areas of innovation activity not captured by R&D expenditures which may indicate a more significant role for SMEs, or that R&D and patenting may be important in certain specific cases.

Instead of focusing on inputs into the innovation process in the form of R&D, it is also helpful to look at the incidence of innovation outputs. As with the R&D data, it is possible to do this in terms of a distinction between firms employing fewer than 250 people and those employing 250 people or more. The most widely used source of data to provide this sort of information is based on the Community Innovation Survey (CIS). On the basis of the latest published data which relate to CIS 4 and cover the period 2002-4, it appears that 23% of businesses which employed less than 250 employees reported that they had introduced a product innovation in the two year period covered by the survey. In relation to process innovation 8% reported that they had introduced such an innovation. It is important to note that the CIS survey does not cover the smallest firms, so that these results relate to businesses employing between 20 and 250 employees. The proportions of innovative firms in this smaller sized category can be compared with those employing more than 250 employees. In this case, we find a much higher rate of innovative activity. Thus, in the case of businesses employing over 250 workers, over 39% reported a product innovation and the proportion reporting process innovations was similarly higher at 14% (DTI, 2006).

There are as we have seen many more small enterprises than there are enterprises employing more than 250 workers. It could thus be argued that the percentage of such small businesses reporting innovation activity reflects a very high importance in terms of numbers of businesses when aggregated up to the national level. That is true, but it is equally true, that when the data is aggregated to national level using weights based on the size of the businesses in terms of employment or value added, then once again the predominant position of the larger businesses reasserts itself (DTI, 2006).

Before turning to a more detailed analysis of SMEs innovation and patenting, we briefly review the arguments for patenting by firms generally.

3. Why should firms patent or not patent?

The public good nature of knowledge as an intangible asset (Arrow, 1962) requires the setting up of institutional mechanisms capable of ensuring a reward for inventors for risky investments which may be reduced if others can freely copy a 'successful' innovation and where there are weak or no gains from being first to market. Patents grant a temporary monopoly on the exploitation of knowledge. Patents are not, however, a necessary and sufficient condition for the translation of invention into successful commercial innovation. Innovation defined in the Schumpeterian sense of the commercial exploitation of new knowledge or inventions is tied to the market place and successful appropriation of value may require many complementary assets in addition to patent protection *per se.*

Hall (2009) sums up the benefits and costs of patents by distinguishing their effects on competition from their effects on innovation. To grant firms temporary monopolistic rents for proprietary ideas means to reduce the level of competition in the sector. The compensating positive effect is that strong IP protection from a patent can facilitate firm entry in an industry dominated by non-innovative incumbents. It can also positively affect competition because it renders technologies tradable. This is an important precondition for the existence of markets for technology, which work on the twin principle that knowledge can change hands and that for the purposes of business the best user of an invention is often not its inventor (Gambardella et al. 2007). From the viewpoint of innovation, patents are beneficial because they generate an incentive to invest in R&D and as a consequence increase the likelihood of innovation in the economy. They exert a negative effect on innovation in those circumstances where technical progress significantly depends on knowledge recombination, where inventions have cumulative nature, and when patents restrict competitive access to the development of challenges to existing dominant positions (Mazzoleni and Nelson, 1998; Bessen and Maskin, 2009).

3.1 Alternative means of appropriability

As far as appropriability is concerned, patents are not the only instruments firms might decide to use to protect the returns to their investments in innovation. A range, as well as a combination, of strategies can be implemented. Intangible assets, such as intellectual property, certainly have high informational content, but the pool of resources necessary to innovate is much richer. Furthermore, the many possible degrees of tacitness in the knowledge that is required through the

innovation process (Antonelli, 2001; Foray 2004) make the choice of patenting as the innovators' preferred mode of appropriation of value from knowledge far from obvious, and need to be considered along with a number of other strategic and environmental factors. These factors include, for example, the characteristics of the technology, the complexity of innovation process, the relevant phase of firm growth and industry effects.

Among alternative means of appropriation are *secrecy*, acquisition and exploitation of *complementary assets*, and *time to market*. Patents provide the inventor with legal protection, but as public documents they also reveal to competitors most of the details for any given invention. It is often the case that imitation is still possible without infringing an incumbent innovator's rights: the nature of the technology might make it possible to 'invent around' a particular design or technical specification (Mansfield, 1986). From the viewpoint of the inventor, this is a case where secrecy can be a more appropriate means to capture the returns to R&D. This might be especially useful when the nature of the invention is incremental and related to a new process as opposed to a new product. Availability of complementary assets (Teece, 1986) is also crucial for effective commercialisation of innovations and specific strategies of asset acquisition/management need to be in place when firms lack, for example, marketing or production capability, or complementary equipment or licences necessary to gain full economic returns from their investments. Discrete inventions are better suited to patents than to complex and technologically distributed ones (Cohen et. 2000).

Lead-time advantages are yet another way to protect IP. They are often used in combination with secrecy. Lead-time – or first-mover – advantages stem from the decision to launch a new product or service in the marketplace before any other competitor. It is a risky strategy (the market is 'untested') but first-movers can benefit from valuable reputation effects and from cumulative learning processes much earlier than rival firms active along a similar technological trajectory and operating in the same market. First-mover advantages are especially powerful when first-entrants manage to establish a market standard or dominant design early on in the competitive process (Utterback, 1994). Naturally, this kind of IP appropriation strategy, like secrecy or the exploitation of complementary assets, is seldom used in isolation. Patents are often used jointly with non-legal instruments such as design complexity and speed to market a complementary strategy to protect intangible capital (Laursen and Salter, 2005).

3.2 IP and sectoral innovation regimes

A large body of evidence demonstrates that the role of patents varies greatly from sector to sector of the economy. The findings from different innovation surveys are quite consistent on this point. The Yale (1983) and Carnegie Mellon (1994) Surveys, both focussed on US manufacturing, show that patents are highly concentrated in a few industries, namely pharmaceutical, biotechnology, medical equipment, chemicals, computers and special purpose machinery.[1] The returns to patenting relative to the decision not to patent are also only positive for the above sectors (Arora et al. 2003). Patents in these sectors are, moreover, often filed not so much with the aim to protect IP *per se* (that is with the intention to bring a novel idea to market) but for strategic reasons, including reputation, cross-licensing and bargaining power. Furthermore, their effectiveness is related not only to the nature of the knowledge they capture in a codified form, but also the product or process orientation of the invention.

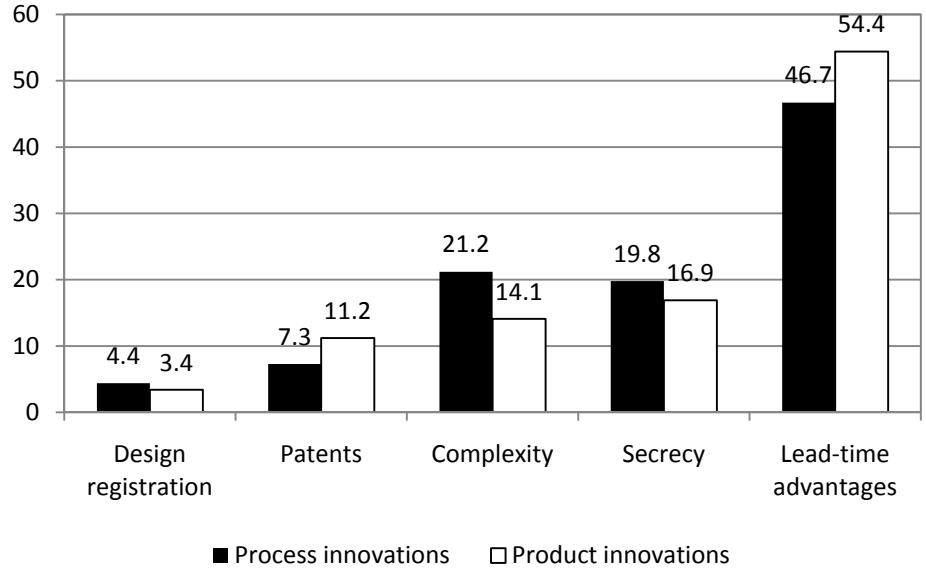
Evidence from European studies does not differ substantially from the US. The MERIT PACE Survey (Arundel et al. 1995) and several iterations of the Community Innovation Surveys provide support for significant effects of sectoral innovation regimes upon firms' IP appropriation strategies. We leave to the specific chapter in this volume the task to discuss in detail the sectoral aspects of patents and we turn to the specific patenting behaviours of SMEs with respect to, but not limited to, the factors we have so far introduced in our discussion.

4. Patents and SMEs:

4.1 The use of patents for IP appropriation and as an Information Source

In a much cited study of IP protection strategies in Europe Arundel (2001) analysed data from the 1993 Community Innovation Survey. Figure 2 reports the percentage of (all-size) respondents that indicated each of the methods (lead-time advantages, secrecy, complexity of innovation, patents and design registration) as the most important strategy. Lead-time is clearly the preferred choice for both product and process innovation, while patents rank second-last among the available options.

Figure 2. Percentage of R&D-active firms attributing highest score to different appropriation mechanisms



Source: adapted from Arundel (2001)

When only patents and secrecy are considered, firms' preferences tend to be for secrecy and this pattern is very stable across firm sizes (Table 2). Secrecy is, however, even more important for smaller firms relative to larger ones than patents. The negative association is statistically significant (Arundel, 2001, Table 2 p.60).

Table 2. Relative importance of patents and secrecy for all R&D-performing firms in 1993 in Europe (% Firms, standard errors in parentheses)

Employees	***N***	**Product innovations**			**Process innovation**		
		Patents more important	Equal importance	Secrecy more imp	Patents more imp	Equal importance	Secrecy more imp
<20	183	17.5 (2.8)	38.3 (3.6)	44.3 (93.7)	10.4 (2.3)	40.4 (3.6)	49.2 (3.7)
20-49	386	17.6 (1.9)	23.6 (2.2)	58.8 (2.5)	12.4 (1.7)	27.5 (2.3)	60.1 (2.5)
50-99	452	23.0 (2.0)	28.5 (2.1)	48.5) 2.4)	11.1 (1.5)	37.4 (2.3)	51.5 (2.4)
100-249	668	20.7 (1.6)	28.0 (1.7)	51.3 (1.9)	11.8 (1.3)	35.9 (1.9)	52.2 (1.9)
250-499	479	20.5 (1.8)	30.1 (2.1)	49.5 (2.3)	12.3 (1.5)	29.6 (2.1)	38.0 (2.3)
500-999	319	24.5 (2.4)	24.8 (2.4)	50.8 (2.8)	9.7 (1.7)	23.2 (2.4)	67.1 (2.6)
1000-1999	186	23.7 (3.1)	33.9 (3.5)	42.5 (3.6)	10.8 (2.3)	30.6 (3.4)	58.6 (3.6)
> 1999	179	30.7 (3.5)	26.1 (3.3)	43.2 (3.7)	19.9 (3.0)	23.3 (3.2)	56.8 (3.7)

Source: Adapted from Arundel (2001)

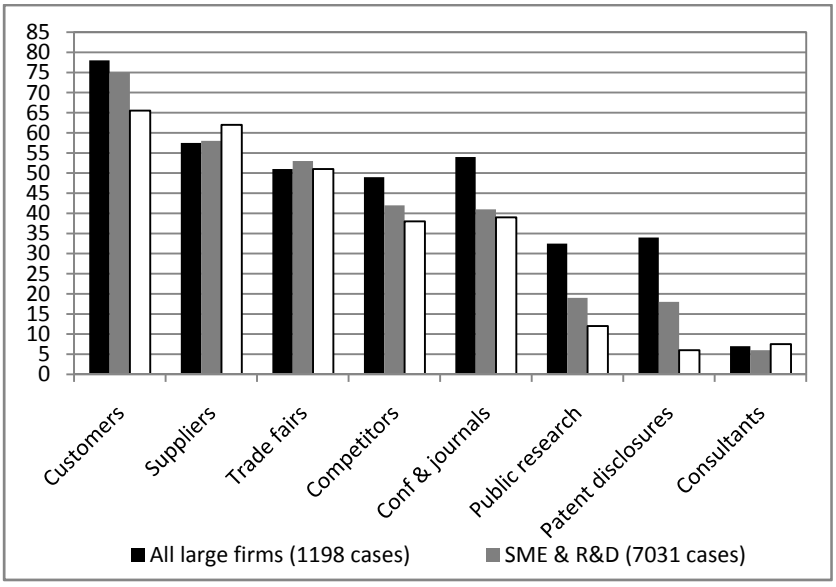
When firms with high R&D intensity are considered, Arundel (2001) also finds that these high R&D intensive firms have a stronger preference for patents compared to the average of the broader sample of all R&D-perfoming firms, but secrecy is still scored higher across all firm sizes. Moreover, this data shows that smaller firms are still less likely to use patents and more likely to use secrecy than larger firms.

In an ordered logit multivariate analysis, not reported in detail here, and controlling for other factors that might affect the choice of IP appropriation mechanism, Arundel finds that 1) R&D intensity loses its predictive power in the choice between secrecy and patents and 2) process innovation-oriented strategies are positively associated with the use of secrecy. Moreover, firms that rely on in-house information for R&D activities are more likely to use secrecy than patents, but the opposite is true for collaborative projects, where the use of patents might make IP ownership clearer. Finally, the relative

importance of secrecy over patents appears to be held valid across sectors. Unfortunately they do not test explicitly for firm size effects.

It thus appears, at least on a univariate basis, that SMEs are less likely than larger firms to use patents and more likely to use secrecy. From the viewpoint of the patenting firm, the patent is a way to protect IP. From the viewpoint of a firm accessing other firms' disclosures, patents are good windows into competitors' R&D activities. Do SMEs use patent documents as sources of information? Again on the basis of CIS data for the period 1990-1992 Arundel and Steinmueller (1998) show that patents are not a very important source of technical information for SMEs[2] compared, in decreasing order of importance, with customers, suppliers, trade fairs, competitors, conferences/journals and public research. For companies that are R&D active patents are even less important than the input of consultants, which is instead relatively more important for SMEs that do perform R&D (SME&R&D in Figure 3).[3]

Figure 3. Importance of Information Sources for Innovation in Europe
(% firms using each source)

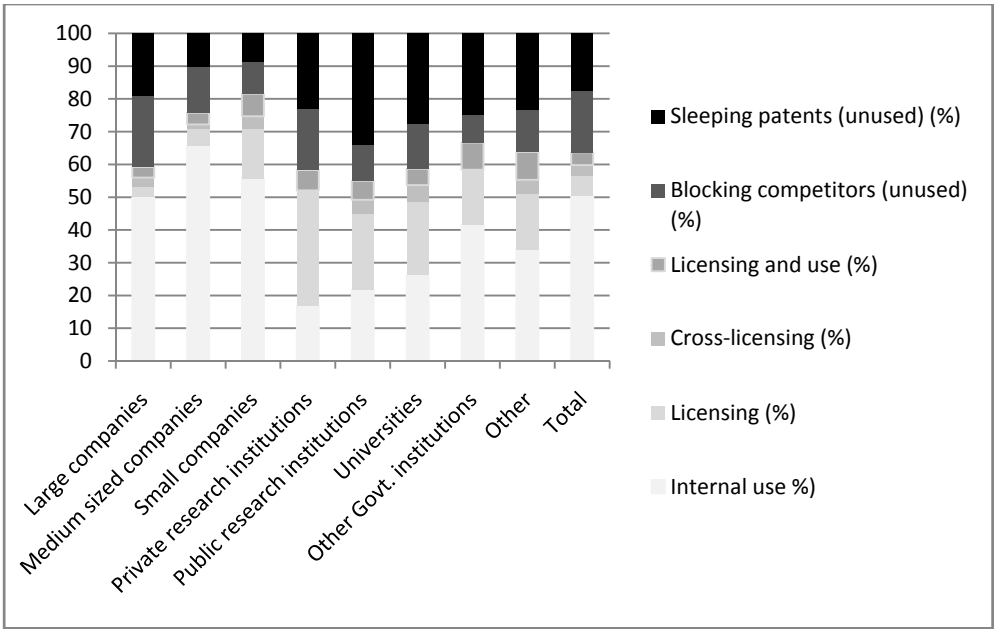


Source: Adapted from Arundel and Steinmueller (1998)

Once firms decide to protect their IP via patent, there are many ways in which a patent can be used. The recent PATVAL survey (Giuri et. al 2007) tested the results of a number of previous studies that had addressed the use of patents 1) to block potential competitors' activities, 2) to trade technological know-how via licensing or cross-licensing and 3) the choice not to use a patent (Arora et al., 2001; Rivette and Kline, 2000; Cohen et al., 2000; Hall and Ziedonis, 2001; Ziedonis, 2004; Arora and Ceccagnoli, 2006).

The survey, conducted between 2003 and 2004, collected information about 9216 patents filed between 1993 and 1997 in six European countries (Germany, France, the UK, Italy, the Netherlands and Spain). Inventors were asked about the use that was made of the patent in the interval between the time of application and the survey observation. Overall, the researchers find that patents are (in decreasing order of importance): used for internal industrial and commercial purposes by the company (50.5%); used to block other companies (18.7%); not used but not 'blocking' ('sleeping' patents: 17.4%); licensed (6.4%); both licensed and internally used by the company (4.0%); used for cross-licensing agreements (3.0%). Interestingly, there seems to be no significant effects exerted by technology macro-classes (Electrical Engineering, Instruments, Chemicals and Pharmaceutical, Process Engineering, Mechanical Engineering) upon this distribution.

There are, however, as Figure 4 shows, differences conditional on firm size.
Figure 4. Use of patents by type of employer in various countries (N=7556)



Data Source: Giuri et al. (2007)

Large firms use for internal purposes 50% of the patents of the survey sample, license 9.2% of them, employ 21.7% to block rival R&D and do not actively (commercial development) or passively (blocking) use the remaining 19.1%. Medium size firms develop a lot more patents for internal use (65.6%), license more or less the same percentage as large firms (10.2%) and have less than half the amount of strategic or dormant patents as large firms. Small firms exploit internally 55.8% of their patents. This is a lower figure than medium size

companies, but higher than for large firms. Smaller firms also have a relatively high percentage of patents that are licences out (15.0%). This latter finding is also corroborated by a parallel analsyis of the same data (Gambardella et al. 2007) that shows firm size is the single most important determinant of the decision to licence out technology and is negatively related to it. Finally, in Figure 4 smaller firms report very low figures for unused patents (9.6% of blocking patents and 8.8 % of dormant inventions).

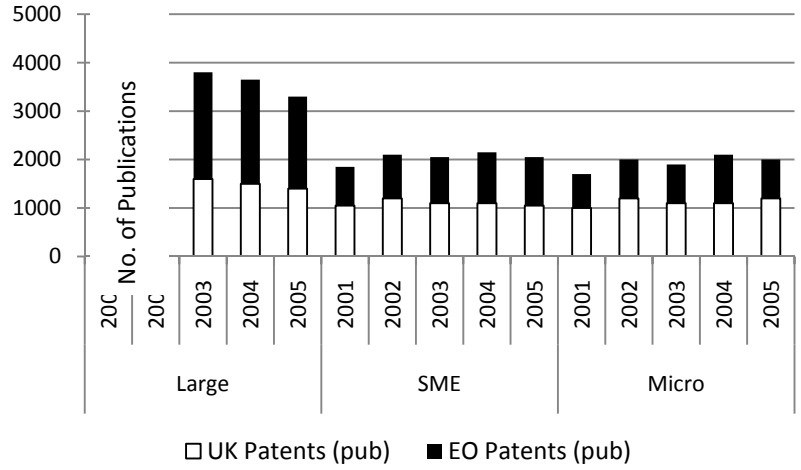
Taken together these results are consistent with smaller firms licensing out more in pursuit of the complementary assets necessary to develop and appropriate value. They are also consistent with an inability or reluctance to maintain sleeping or dormant patents because of the relatively high fixed costs which may SMEs may be unwilling or unable to bear. They thus may patent more viable intellectual property.

4.2 The UK evidence

In this section we focus on the UK economy. First, we report on recent findings by Rogers et al. (2007a and 2007b), who conducted two related studies of the characteristics of SMEs that use intellectual property appropriation methods. These analyses are based on a data set matching FAME records with UK and European patents and with Marquesa Ltd data on UK and European trademarks. The definition of SMEs in this study is based on firms' total assets as opposed to employment. Firms are classified as large when they own total assets in excess of £28.7 million, as SMEs when this figure is between £1.3 and £28.7 million, and as microfirms when asset value is below or equal to £1.3 million. Secondly, we present some independent analyses of CIS-4 data on the patenting behaviour of UK firms, where the definition of SMEs is instead based on employment groups.

Using the FAME data it appears that the number of UK patent publications by all UK registered firms fell between 2001 and 2005 from 4,272 to 3,709, although this is likely to be due to incompletness of 2005 data. Over the same period the number of EPO patents did not change significantly and remained around 4,000 units (Rogers et al. 2007a). Disaggregation of patent publications by firm size shows a relative decrease for large firms using UK patents and minor increases, with the exception of the last year of financial reporting available for this study, in the number of combined publications by SMEs and microfirms taken together, their combined contribution matches or exceeds that of large firms (Figure 5).

Figure 5. Numbers of patents by firm size 2001-2005



Source: Rogers et al. (2007a)

As far as the number of patenting firms is concerned, the same study finds a slight decrease over time in the number of large firms using UK patents, but not EPO patents. SMEs and microfirms seems to be increasingly active, although the number of publications per firm remains on average well below the level of larger firms. The majority of patents are published by SMEs in the following regions, in decreasing order of importance: South East, Greater London and East Midlands.[4] Moreover, SMEs are less inclined than large firms (and also microfirms) to patent jointly with other firms, but are more likely to co-patent with universities. Micro firms are by far the most likely to file joint patents with universities (Rogers et. al, 2007a).

The sectoral distribution of patenting activities is, as is well known, very uneven. By far the top performing aggregate sector by patenting is manufacturing. According to Rogers et al. (2007a), this accounts for 1,734 out of a total of 3,101 UK patenting firms and 1,202 out of a total of 2,423 firms with EPO publications (2001-2005). The next best performing sectors by EPO patents are, in order of importance, R&D services (372), business services (262) and computer-related activities (151). Table 3 reports extracts from the same data at the 2-digit SIC level of aggregation. The majority of UK patenting firms, with some differences in relative rankings, are found in the following sectors: fabricated metal products, furniture and manufacture, machinery and equipment, chemicals and chemical, rubber and plastic, and medical and optical instruments (Table 3).

Table 3. Number of patenting SMEs and average publications in UK manufacturing industries 2001-2005

Manufacturing industry	**UK Pat**	**Av**	**EPO patent**	**Av**
Food and Beverages	10	1.5	12	1.3
Tobacco Products	1	1.0	1	2.0
Textiles	21	1.2	18	1.1
Wearing Apparel	6	2.0	4	1.0
Tanning & Dress, of Leather	1	1.0	1	1.0
Wood and Products of Wood	12	1.6	1	1.0
Pulp Paper and Paper Prod.	23	1.1	14	1.1
Publishing and Printing	44	1.4	34	1.5
Coke and Refined Petroleum	2	1.0	1	1.0
Chemicals and Chemical	107	1.4	158	1.8
Rubber and Plastic Prod.	131	1.5	79	1.4
Other Non-Metallic Minerals	30	1.7	11	1.5
Basic Metals	26	1.3	6	1.2
Fabricated Metal Products	337	1.5	179	1.4
Machinery and Equipment	211	1.5	155	1.4
Office Machines and Compu.	33	2.6	16	2.0
Electrical Machinery	159	1.6	112	1.6
Television and Line Telecom.	94	2.4	81	4.0
Medical and Optical Instruments	168	1.8	154	1.6
Motor Vehicles	33	1.8	21	1.4
Other Transport Equipment	15	1.2	6	1.0
Furniture Manufacture	278	1.3	149	1.3

Source: Adapted from Rogers et al. (2007a)

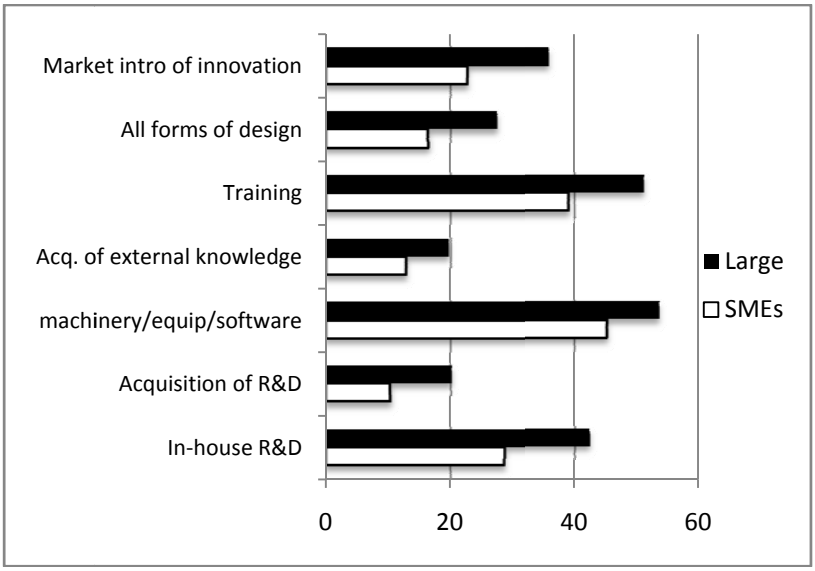
In terms of profitability, large firms active in patenting or trademarking seem to display higher profitability than non-IP active firms, but this does not hold true for either SMEs or micro-firms. The former have lower profitability, the latter negative profitability, compared with non-IP active counterparts (Rogers et al. 2007). This is a likely consequence of the risky nature of R&D investments, the smaller product portfolio of smaller firms and the phase of growth of the firm, whose profits are likely to be generated some time after the initial layout of R&D and other start-up or early growth costs. For the same reasons IP active SMEs are found to be at higher risk of liquidation or receivership than non-IP active SMEs when they exit the market. Overall, the percentage of IP active firms that exit the market is slightly lower than the percentage of IP inactive firms. However, no significant effect is found between IP activity and the probability of exit. Interestingly, joint patenting increases this probability.

Evidence of the effects of IP on growth is mixed, but it appears that these result in a distribution of outcomes that is more polarised towards very good and very poor performance than the case of non-IP active SMEs. A similar polarisation effect is reported in the analysis of the effects of IP on profitability (Rogers et al. 2007b).

Finally, they report lower financial returns than other firms. It thus appears that UK SMEs (on this asset based definition) are in keeping with international studies, less likely to be patenting. They are concentrated in a narrow range of manufacturing in clusters and are more likely located in the South East Greater London and the Midlands and more likely than large firms to co-patent with inventors.

Analyses we conducted on data from the fourth round of the Community Innovation Survey address the question of SMEs' propensity to patent vis-a-vis other means of IP appropriation and its sector-specific trends with a specific focus on the UK. Figure 6 charts the responses by large and small firms to a question about their perceived sources of profits (introduction of innovated products or services in the market place, design, training, acquisition of external knowledge, acquisition of machinery, software or equipment, outsourcing of R&D, in-house R&D). In these calculations we have defined small firms are those with 1-99 employees, medium are 100-999 and large are equal or above 1,000. These classifications are more comparable with the FAME based size classification reported earlier. The percentage of large firms is higher than that of SMEs for each factor, with figures that are most similar for the acquisition of machinery, software and equipment and most different for the acquisition of R&D, with a two-to-one ratio. SMEs in general thus appear less likely to be generating appropriable profits from technology and innovation related sources.

Figure 6. Perceived sources of profits, UK CIS-4, large firms and SMEs 2002-4 (% Firms)



Source: Calculated from CIS4 data

If we turn to the use of IP as an appropriation method Table 4 shows results that are consistent with Arundel's (2001) findings for an earlier period for the EU. Patents are the third least preferred method, followed by design complexity and registration of design, for SMEs in the sample of all UK firms. In the sub-sample of R&D-performing SMEs, patents score better, but still lag behind confidentiality agreements, lead-time advantages and secrecy (Table 4). Table 5 shows patents are more important for product than for process innovations, both for all firms and for those doing R&D.

Table 4. Importance of protection method for all firms and for R&D performing firms in the UK 2002-4

	% of enterprises for whom the method is of high importance		***% of R&D-performing enterprises (Activities=1) for whom the method is of high importance***	
Protection methods	SMEs	Large	SMEs	Large
Registration of design	4.9	10.5	7.3	14.2
Trademarks	6.8	15.3	9.8	19.6
Patents	6	12.9	9.1	17.3
Confidentiality agreements	11.7	21.6	17.3	27.9
Copyright	6.1	9.9	9	12.7
Secrecy	9.3	18.1	13.8	23.4
Complexity of design	5.2	8.9	8	11.7
Lead-time advantage	10.4	16.5	15.6	21.8

Source: Calculated from CIS4 data

Table 5. Importance of protection method for product and process innovation in the UK 2002-4

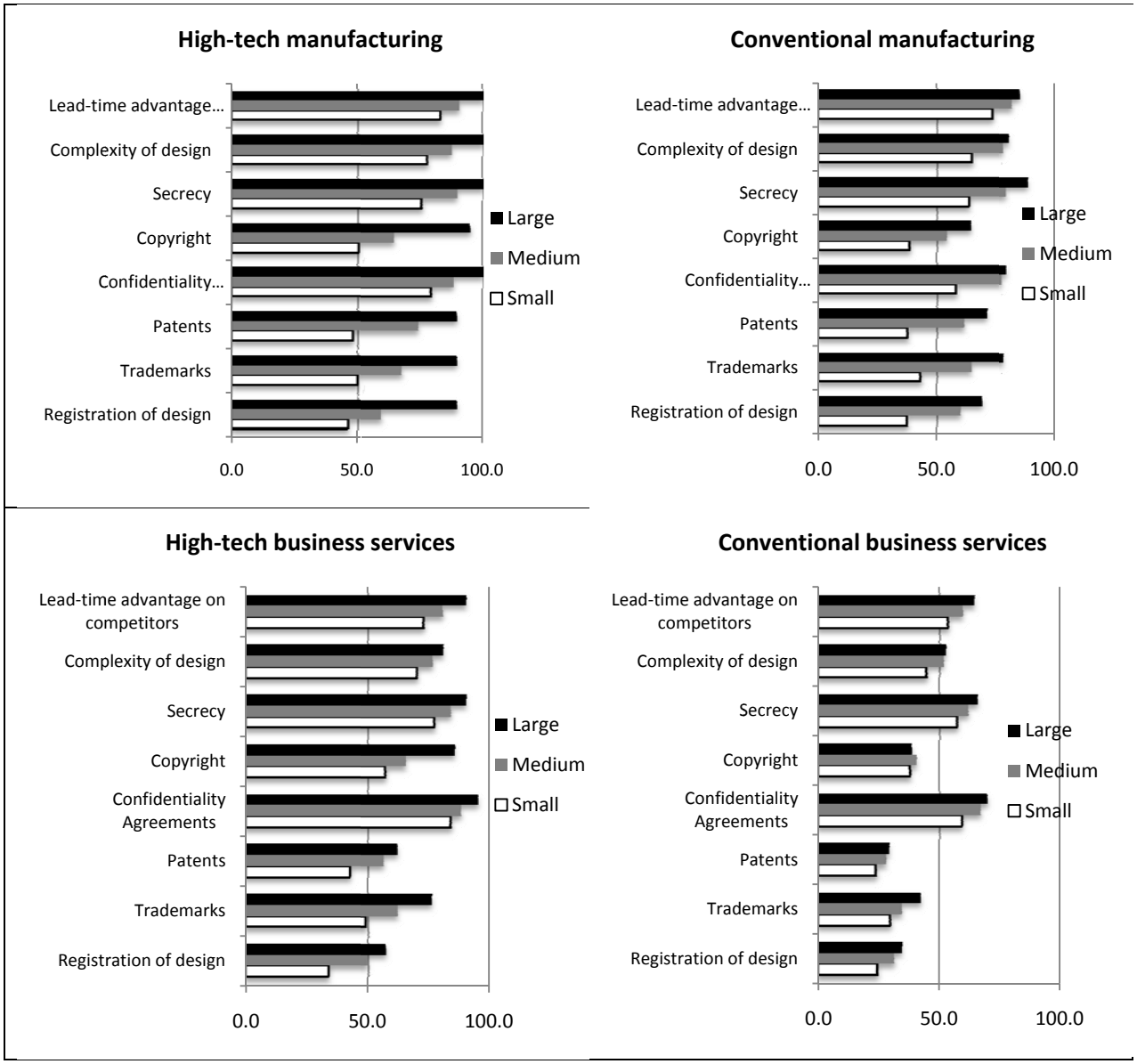
	% of SMEs for whom the method is of high importance		*% of R&D-performing SMEs for whom the method is of high imp.*	
Protection methods	Product innov.	Process innov.	Product innov.	Process innov.
Registration of design	10.6	9.5	10.9	9.6
Trademarks	14.2	12.1	14.7	12.1
Patents	14.1	12.9	14.8	13
Confidentiality agreements	25.8	26.8	26.6	26.8
Copyright	13.3	12.4	13.8	12.5
Secrecy	19.9	20	20.6	20
Complexity of design	13	12.7	13.5	12.7
Lead-time advantage	23.1	23.6	23.9	23.6

Source: Calculated from CIS4 data

It is also possible to check for cross sectoral effects by comparing high technology manufacturing and business services sectors. Thus in Figure 7 we disaggregate the data by classes of technology intensity and distinguish high-tech from conventional manufacturing and high-business services from other services. In the high tech manufacturing group, 47.9 percent of small firms and 74.1 percent of medium size firms report relying on patents to protect IP against 37.3 and 61.6 respectively in the conventional manufacturing group. Lead time advantages (82.2% and 90.4%), secrecy (75.3% and 89.6%) and confidentiality agreements (79.1 and 88.1) are especially important for small and medium size high tech manufacturing firms. Nevertheless, the role of patents gains in importance proportionately to the intensity of R&D for high-tech manufacturing firms (Figure 8).

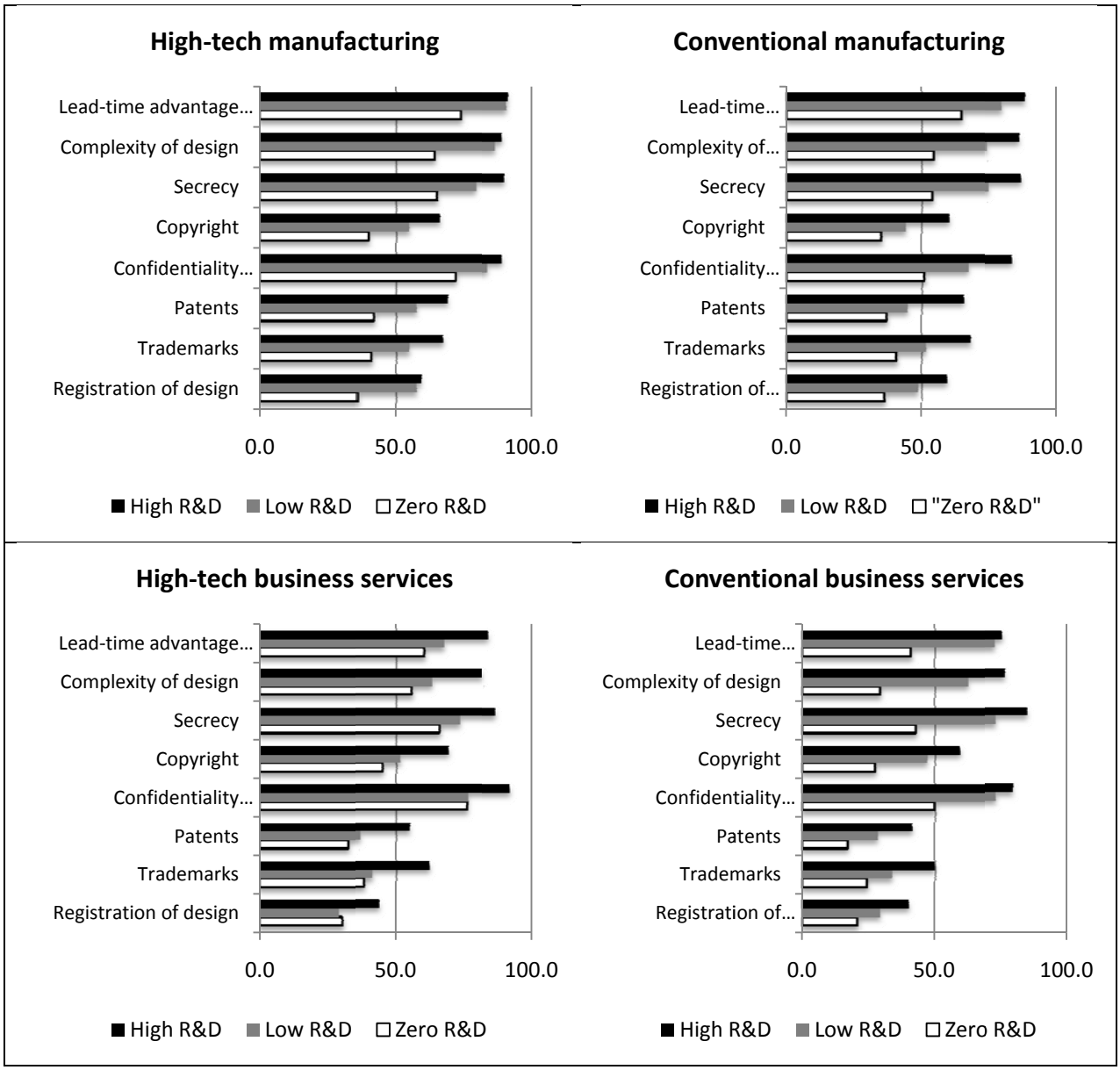
These CIS4 results taken as a whole are broadly in line with our earlier review of studies across international samples, and the UK study based on FAME data.

Figure 7. Percentage of innovators using each IP appropriation strategy in the UK 2002-4



Source: Calculated from CIS4 data

Figure 8. Percentage of innovators using IP protection by R&D intensity in the UK 2002-4



Source: Calculated from CIS4 data

Innovative SMEs and the protection of IP in the UK and the USA

So far we have considered innovation activity across Europe and in the UK. In this section we focus on a comparison between the UK and the USA using a unique set of data on small firms in the two countries (for full details on the survey see Cosh, Hughes and Lester (2006) and Cosh and Hughes (2010)). The survey covered manufacturing and business services and the results reported here relate to small firms defined as those employing between 10 and 99 employees in the UK and the USA in 2004-5. The results are based on a sample of these small firms drawn from a size and industry matched sample of around

900 businesses in each country and which reported innovative activity in the previous 3 years. The full sample displayed the same variations across size classes in both countries in relation to the acquisition of patents and licences, patenting activity and the use of various protection methods as revealed in the previous sections of this chapter. We therefore focus only on the results for the smaller businesses in this section.

It is useful to begin by looking at the extent to which innovative small businesses in the UK and the US engage in the acquisition of patents and licences. As Table 6 shows, the vast majority of innovative small firms never engage in this activity. If anything, the proportion never doing it is higher in the US than in the UK. Around 29% occasionally engage in this form of activity in the UK compared to 29.8% in the US, whereas in both countries only around 7% do so continuously.

Table 6. Frequency of engaging in: Acquisition of patents & licenses (Innovators only)

	Never	**Occasionally**	**Continuously**	**Total**
UK: 10-99	63.8	29.0	7.2	100
US: 10-99	70.6	21.8	7.6	100

Source: Calculated from the CBR/IPC international innovation benchmarking dataset

If we turn to a related question of the extent to which firms engage in the purchase of specialised services in relation to patenting advice and training we find a very similar pattern in both countries. Such activities are only occasionally indulged in by smaller innovative businesses.

Table 7. Frequency of engaging in: Purchase of specialised (Non R&D) services from outside such as patenting advice, training (Innovators only)

	Never	**Occasionally**	**Continuously**	**Total**
UK: 10-99	43.6	46.9	9.5	100
US: 10-99	41.9	49.3	8.8	100

Source: Calculated from CBR/IPC international innovation benchmarking dataset

5. Innovative SMEs and the protection of IP in the UK and the USA

So far we have considered only the frequency of activity. A rather different picture emerges if instead we look at the percentage in total innovation related expenditure spent on acquisitions of patents and licences. It appears that in this case small US firms, although somewhat less likely to be engaged in this activity than small UK firms, nonetheless spend somewhat more. This is also true in the case of the largest firms.

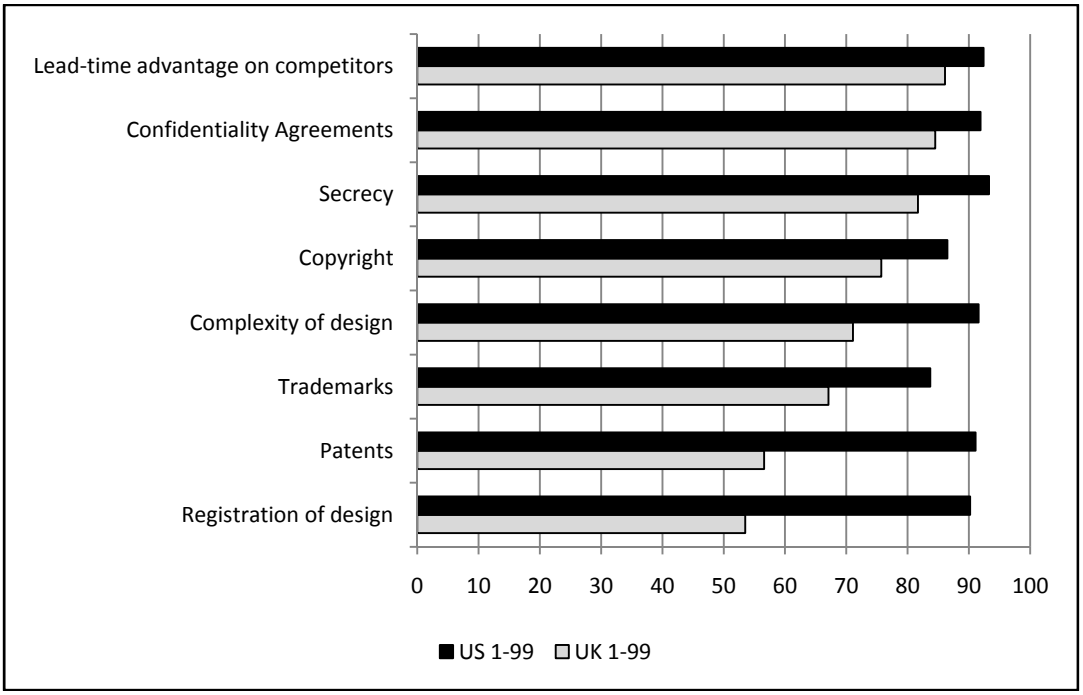
Table 8. Percentage of total innovation-related expenditure in the last financial year spent on acquisitions of patents and licenses (Innovators only)

Size	UK	US
1-99	0.9	1.4
100-999	2.8	1.5
1000+	2.0	3.6

Source: Calculated from CBR/IPC international innovation benchmarking dataset

We can now turn to the relative importance of different methods of protection in use in innovative SMEs in the UK and the US. Figure 9 presents some data on this which shows the percentage of businesses in the matched sample rating each method of protection that we have looked at in previous sections as important or highly important. These results are not directly comparable with those in earlier sections, because this set of results focuses on a matched sample of innovating small firms only. It is striking that where US companies use a method of protection, they are more likely to rate it as highly important. However, from the point of view of patenting, it is noticeable that this is one of the areas where UK firms are much more likely to rate its use as less highly important than their US counterpart. Thus Figure 9 shows that registration of design, patents and trademarks are all relatively lowly ranked in importance in the UK innovative SME sector compared to the US.

Figure 9. Methods of Protection: Innovative SMEs of the UK and the US (% users rating it as important or highly important)



Source: Calculated from CBR/IPC international innovation benchmarking dataset

Finally, Table 9 shows that the relatively low value placed on patents as an important source of protection in the UK is also reflected in the relatively low number of patents granted to firms in the matched innovative sample in the last three years. US firms are much more frequent patenters. In the case of innovative small firms on average twice as many patents are granted in the US as in the UK, although the number is only around 1 patent every three years. For the largest firms the average number of patents in the US is over 48 in the last three years compared to just less than 20 in the UK.

Table 9. Number of patents firm granted in last 3 years (Innovators only)

Size	**UK**	**US**
1-99	0.7	1.3
100-999	2.2	5.1
1000+	19.7	48.1

Source: Calculated from CBR/IPC international innovation benchmarking dataset

The relatively low value placed on patenting in matched samples of smaller businesses in the US and the relatively low level of patenting activity are interesting differences and merit further investigation. We discuss some possible factors in the next section.

6. The functions of patents and the role of the patenting system for SMEs: Overview

We have argued that patents may serve a variety of purposes. The vast majority of research efforts have focussed on the protection of innovation-related intangible assets. This function captures the role of patents in contributing to the innovation performance of firms. Here the evidence we have reviewed suggests that in aggregating the use of patents as a means to construct and protect proprietary know-how is not the preferred choice of firms. Despite much emphasis on patents both in the economic literature and in the policy debate, secrecy and lead-time advantages seem to be much more important and this is especially so for smaller firms. The sectoral dimension is, however, important, and the number of sectors where patents are necessary to generate and sustain firms' competitive advantage are few and concentrated in high-tech and science-based markets.

Patents, as we have seen, also are detailed sources of information. The information function of patents consists in their capacity to disclose and disseminate know-how about competitors' state-of-the-art products and processes. Patents could in principle be used as learning inputs by firms seeking to monitor and/or imitate their competitors' innovative behaviours. However, this function does not appear to be especially important, least of all for SMEs.

Firms appear to have good incentives to patent for strategic reasons. Patenting in telecommunications equipment or semiconductor, unlike, for example, in the chemical sector, is often motivated by the strategic objective to block competitors' R&D activities and create a position of advantage in eventual negotiations for IP ownership or use (Cohen et al. 2000; Hall and Ziedonis, 2004). The findings of the PATVAL survey we have reported in Section 3 provide a recent interesting quantification to this phenomenon in the European region. The data show that small firms make relatively little use of blocking patents, probably yet another sign of the higher marginal costs of patenting with respect to larger firms.

Finally, there is an emerging strand of empirical research, building on Mazzoleni and Nelson (1998), according to which firms, and especially SMEs, make use of patents to signal their growth prospects to potential investors. These increasingly take patents as an important determinant in the selection of

portfolio choices. Lerner (2004), for example, showed that patents generally have a positive impact on company valuation. This effect seems to be particularly important for smaller firms. It is perhaps this phenomenon that captures a strong, and often neglected, effect of the patenting system on SMEs' behaviours. In a very recent study on the ability of new firms to attract venture capital investment, Haeussler et al. (2009) find that patents work as risk-reducing signals for potential investors interested in the company. Their results, based on a study of the German and British biotech sectors, show that the presence of a patent application accelerates VC investment because investors explicitly consider information that is generated through the patenting process as very valuable to their decision. Again, this effect of the patenting system is arguably strongest in specific high-tech sectors.[5] This is certainly an area where further investigation is needed.

Overall, the role of patents as economic incentives to innovate by protecting the returns to R&D, disseminating information, defending competitive advantage or signalling value, also depends on the quality of enforcement mechanisms. From the viewpoint of SMEs the costs of IP enforcement quite clearly works against the use of patents.[6] Moreover, infringements are a significant problem especially for SMEs. Two separate studies by Rodwell et al. (2007) and Kingston (2004) highlight the extent of the problem and report that the vast majority of European SMEs (75 and 67 percent respectively) had experienced some form of IP abuse. These figures might be affected by sizable response selection biases (and the sample for the 2007 study was also rather small), but do nevertheless provide some evidence on the problem.

In some cases, instances of infringement go to litigation. Although data on litigation are rare and patchy there is some relevant literature showing that:

1) the number of cases depends on the costs of litigation relative to the size of the market. The UK has high litigation costs and a low level of litigation compared to the US, Germany, France and the Netherlands (Mejer and van Pottelsberghe des la Potterie, 2009);

2) litigation rates vary significantly by sector and firm size. SMEs, which tend to have smaller patent portfolios, are more vulnerable to litigation and tend to be sued by, as opposed to sue, larger firms[7] (Lanjouw and Schankerman, 2004, Ball and Kesan 2009, among others). This is probably because of their inferior bargaining power, information asymmetries about the IP process, or the higher marginal value they attach to their patents.

The number of patent applications is increasing and concerns have been expressed about negative trends in the quality of patent publications, which is

not unrelated to strategic uses of patents. The number of litigation cases is also increasing and patent offices are under pressure to adapt to these trends. Harhoff (2009: p. 17) observes:

A badly designed litigation system may encourage extortionary practices, again counteracting the intended positive effects of IPRs. The best IPR court and litigation system should resolve cases fast and at low cost; it should create as few opportunities as possible for influencing rivals' costs of litigation (e.g. by use of mechanisms like discovery of evidence); it should seek to bring the required expertise (in many cases that means technical knowledge) into the judges chambers; and its cost allocation rules need to lower the risk that frivolous litigation is instigated by cash-rich parties against financially less well-off opponents.

This is as true for the European patent and litigation system as it is for national systems, including the UK. On average, the costs of applying for a patent in the European area are between 3 and 5 times higher than in the US and Japan. A solution to this, as Harhoff again clearly points out, is not only to reduce costs but also and above all to create a quality-oriented system on the principle that innovation does not need stronger patents as much as higher-quality IP.

Critics of the current patent systems argue that these are unsympathetic towards the needs of small and medium size enterprises. This is because they are modelled on the characteristics of few sectors – epitomised by the pharmaceutical innovation model – that are not representative of the innovation dynamics of the rest of the economy and of the vast majority of SMEs (MacDonald, 2004). The recent Gowers report (2005) addressed some of the problems that had been identified in the UK system and made recommendations to guide incremental change in the system. The report suggested, for example, improvements in the information infrastructures that could help SMEs to overcome their resource constraints and intensify their IP protection activities. To reduce the costs of litigation, it also recommended the use of fast-track litigation with clear limits for fees, disclosure and duration of the proceedings. It also pointed to the advantages of harmonised action at the European level through the Community Patent, a European Patent Litigation Agreement and a specialised European Court for international cases.[8] Concerns have, however, emerged from the UK SMEs entrepreneurial community that significant problems remain and need attention. Although evidence is anecdotal and unsystematic, the structure of cost and fee repayments, the contestability of granted IP and the provision of independent expert advice in Court are three points where further research and appropriate action might be required.

7. Conclusion

In this chapter we have discussed the rationale for SME patenting behaviour. We considered a variety of views on the role of patents in innovation and considered the arguments for and against expecting patenting by SMEs, their preferences and behaviours, and the sector-specific distribution of their patenting activity. We also discussed the functions of patent for innovation, information, defence/strategy and selection/signalling. We reported evidence from a number of different surveys, provided some new statistics on the innovation strategies and practices of UK SMEs based on UK Community Innovation Survey data and the UK-US CBR/IPC benchmarking survey. We concluded with some considerations on the functions of and emerging challenges for the patent system. Multivariate analysis of the UK-US benchmarking survey is underway and extended results, soon to be available, will strengthen the case.

The interpretation of the data we have reviewed and presented is consistent with some potentially adverse effects of the IP system on SMEs which could discourage them from patenting. To the best of our knowledge, there are, however, no studies which systematically address the role of the costs and benefits of IP protection for UK SMEs on a multivariate basis which could clearly distinguish this effect from other factors, such as lack of internal capability to recognise or exploit patents, or otherwise reduce the commercial appropriateness of using patents as part of their business model. Thus, the relative impact of the specific features of the UK system compared to other factors determining the choice of IP versus other methods of developing and appropriating value remains an important area for empirical study.

Notes

[1] See Mansfield (1986)
[2] Companies with employment comprised between 10 and 499 people are here classed as SMEs.
[3] The authors also find that overall the reliance of firms on patents as sources of information is sector-dependent.
[4] The geographical distribution of patents is arguably dependent on the distribution of the broader UK economic activities and on the sectoral patterns of industry localisation.
[5] Another sector where this effect is found is semiconductors (Hsu and Hall, 2008).
[6] For an extensive review of this topic, a recent SABIP report provides good coverage of the relevant literature (Webster et al. 2009)
[7]Although Lanjouw and Schankerman's study for the US (2004) find that they are not disadvantaged as far as litigation outcomes are concerned.
[8]These recommendations, as well the broader terms of the enforcement problem, are addressed in more detail in the recent SABIP report on 'IP Enforcement in the UK and Beyond: A Literature Review' by Weatherall et al. (2009).

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