The importance (or not) of patents to UK firms*

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Abstract

A surprisingly small number of innovative firms use the patent system. In the UK, the share of firms patenting among those reporting that they have innovated is about 4%. Survey data from the same firms support the idea that they do not consider patents or other forms of registered IP as important as informal IP for protecting inventions. We show that there are a number of explanations for these findings: most firms are SMEs, many innovations are new to the firm, but not to the market, and many sectors are not patent active. We find evidence pointing to a positive association between patenting and innovative performance measured as turnover due to innovation, but not between patenting and subsequent employment growth. The analysis relies on a new integrated dataset for the UK that combines a range of data sources into a panel at the enterprise level.

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1. Introduction

One of the most puzzling findings in the empirical analysis of firms' patenting behaviour is the low proportion of patenting firms in the population of registered companies. Our investigation of this phenomenon in the UK finds that only 1.6% of all registered firms in the UK patent and that even among those that are engaged in some broadly defined form of R&D, only around 4% have applied for a UK or European patent during our period of analysis (1998-2006).[1] In our data, even in high-tech manufacturing sectors, which arguably produce the most patentable inventions, the share of patenting firms in the UK does not surpass 10%. Restricting the high-tech sector to R&D-doing firms that also innovate, the share of patenting firms increases only to 16%. Findings for the US are similar: Balasubramanian and Sivadasan (2011) find that only 5.5% of US manufacturing firms own a patent. Moreover, shares of patenting firms differ dramatically across sectors – even within the manufacturing industry; for example in the UK, manufacturing of chemicals and chemical products has a share of around 10% of patenting firms whereas publishing and printing has a share of only around 1%. This suggests that (a) some firms do not automatically patent all of their patentable inventions, (b) some firms avoid the patent system altogether, either because of its cost or because patenting is perceived to yield no additional benefit, and (c) some innovations involve inventions that are not patentable.

In this paper we investigate three questions whose answers may shed some light on the reasons that relatively few firms patent. First, we look at the determinants of the perceived importance of patents and other IP mechanisms for securing the returns to innovation, as self-reported by firms. Second, we relate the actual, observed decision to patent to a set of firm characteristics and the perceived importance of patents to the firm and in the firm's sector. Finally, we ask whether patenting is associated with better innovative performance or with higher employment growth, controlling for many other factors. If it is, that suggests that the low patenting rate is of concern, whereas if patenting has only a limited association with performance, that could explain why relatively few firms find it worthwhile.

[1] European means a patent that was filed with the European Patent Office (EPO).

The analysis is based on a new firm-level dataset that combines detailed information on firms' self-reported innovation activities from the UK Community Innovation Survey (CIS) with firms' actual patent and trademark holdings. The combination of the different data sources allows us to overcome a number of problems that have plagued existing work on the determinants of a firm's patenting propensity. If patent data are available but not information on a firm's innovative activities, strong assumptions regarding firms' underlying innovative activities are required in order to measure a firm's patenting propensity.[2] However, even when data on innovation input such as R&D are available, it is empirically difficult to determine whether patenting propensities differ due to differences in unobserved productivity, i.e., the way R&D is translated into patentable inventions, or due to genuine differences in patenting propensities (Brouwer and Kleinknecht, 1999). The availability of some information on innovation output, together with data on a firm's actual patent applications, allows us to partially overcome this problem and to assess the determinants of a firm's decision to patent conditional on innovating. Although innovation is possible without necessarily having patentable inventions, innovating firms are more likely to possess such inventions. There are few existing analyses of observed patenting behaviour that are able to control for the presence of an invention; most of those available use spending on R&D as a proxy for innovative activity. However, formal R&D is only a proxy for firms' innovative activity as inventions may result from a range of (even routine) activities and is therefore not exclusively an outcome of the targeted effort of R&D. As we show empirically later in the paper, this phenomenon is more likely in service sectors than in manufacturing, the traditional sector studied using the R&D proxy.

Despite these advances, our data is still of observational nature, that is, the variables of interest are subject to companies' endogenous choices. A company's decision to protect a specific invention through a patent or an alternative protection mechanism is far from random. This limits our ability to identify causal mechanisms that determine a firm's decision of how to appropriate returns to inventing and innovating. We are, therefore, constrained to pointing to robust empirical patterns in the data. This is a major shortcoming that applies to the literature on the decision to patent and its implications

[2] The required assumption is that firms face the same decision conditional on a range of observable characteristics, that is, they have similar inventions that they can patent or protect in a different way such as maintaining them secret.

more generally due to the absence of experiments.[3] In addition, although in principle we have a panel data set for analysis, the CIS resamples for each survey, so that the resulting panel is highly unbalanced. Thus exploiting variation over time is of little help in achieving identification of the parameters of interest.

Our results show that in general innovation of any kind is negatively associated with a preference for patents over secrecy or formal IP over informal IP, although the association is weakly positive in the case of manufacturing and very negative in Knowledge-Intensive Business Sectors (KIBS). Patent propensities vary greatly across type of innovation, firm size and industry. The most important, and well-known, explanation of the low overall propensity to patent is that most firms are small and small firms are unlikely to patent. Another reason is that most UK firms are in sectors where patenting is not used much or where innovative activity is low. In addition, firms are less likely to patent if they have process innovations or innovations new to the firm, but not the market (as one might expect). Third, we provide some empirical evidence on the relationship of a firm's patenting decision to its subsequent performance and find that patents are positively associated with innovative sales performance but not significantly with employment growth. Thus there is some suggestion that they are associated with more successful innovations but not with overall performance.[4]

This paper is organised as follows. Section 2 briefly summarises the relevant literature that is based on the analysis of CIS data. Section 3 describes the structure and content of the dataset used for the analysis. Section 4 provides descriptive evidence on our principal research questions. Section 5 outlines our empirical approach and Section 6 discusses the corresponding results. Section 7 summarises the main findings.

[3] In the context of patents it might not even be obvious how a randomised intervention should be designed to yield meaningful insights. Yet there is scope to exploit exogenous variation induced by policy interventions or idiosyncratic shocks to identify the effect of the variable of interest. In the innovation literature, examples exploiting such natural or quasi-experiments are rare. Exceptions include Scherer and Weisburst (1995) who use a decision in 1978 by the Italian Supreme Court ruling an existing law unconstitutional that excluded pharmaceuticals from patent protection in Italy to identify the effect of patent protection on innovation measured as R&D and U.S. patents. In a similar study, Sakakibara and Branstetter (2001) use a change in the Japanese patent law to identify the effect of the strength of patent rights protection on firms' R&D expenditure and patenting activity.

[4] However, our empirical framework is not suited for making counterfactual statements, i.e., we are unable to say whether patenting and innovative performance would still be positively correlated if more firms patented.

2. Literature

In this section, we briefly review a number of studies using CIS data on innovations to study patenting.[5] This is useful to frame our analysis within the existing research and to compare our results with existing findings. Hall et al. (2012a) offer a broader review of the existing literature on firms' choices between formal and informal IP. As we discuss there, both the theoretical and empirical literatures focus on the trade-off between secrecy and patenting, primarily because other methods of IP protection are likely to be complementary and used together, rather than obvious substitutes as in the case of secrecy and patenting.[6]

Brouwer and Kleinknecht (1999) uses the CIS 1 data (for the Netherlands) to study the determinants of a firm's decision to patent. The Dutch CIS 1 data also contain information on firm's patent holdings, which allows Brouwer and Kleinknecht to investigate the determinants of a firm's actual patent holdings. They find firm size, R&D intensity, sales of innovative products, and R&D collaboration agreements to be positively correlated with a firm's patenting propensity. Also firms in high-tech sectors appear to have higher patenting propensities. Arundel (2001) uses CIS 1 data for seven European countries to show that the propensity to use secrecy relative to patents falls with firm size (measured as R&D expenses and employment) for product innovations, while the association is much weaker for process innovations.

Pajak (2010) uses firms' responses in the French CIS 4 on the importance of different protection methods to evaluate the determinants of a firm's choice between patenting and secrecy. His main variables of interest in determining a firm's choice are firm size and the size of the inventive step. As expected, Pajak finds that the use of patents is increasing in a firm's size (measured as employment). Moreover, for his sample of small firms in intermediate goods sectors, Pajak finds that firms reporting innovations new to the firm are more likely to use patents, whereas the same firms seem to prefer secrecy

[5] There is a large earlier literature on the determinants of patenting in manufacturing which emphasizes the role of R&D, exemplified by Scherer (1965) and Bound *et al.* (1984) that we do not review in the interest of brevity. For work that surveys firms on their use of IP, see Mansfield (1986), *inter alia*.

[6] As discussed in more detail in our literature review, it is also true that the use of patents and secrecy may be combined. For example, different components of an invention may be patented whereas others, such as the production method, may be kept secret. Alternatively, patent applicants may attempt to obscure enablement in a patent applications by for example increasing the complexity of filings.

for inventions new to the market, which he considers in line with the theoretical predictions of Anton and Yao (2004). This empirical finding should be interpreted with caution, however, as the sample size is small (72 firms) and the share of innovating small firms is less than 10%. The results presented in this paper point to the opposite conclusion.

Heger and Zaby (2013) use data from the Mannheim Innovation Panel (MIP) (which represents the German CIS) to offer an explanation for the empirically observed variation in patent propensities across companies. The empirical analysis of patenting propensities is possible because the MIP contains firms' self-reported innovation measures as well as data on their patent applications. The authors show theoretically and empirically that the decision to patent depends on the effect on competition associated with the disclosure of information required by a patent. This effect varies across firms because it depends on the competitive advantage of companies. This variation in the cost of disclosure due to a patent translates directly into variation in patent propensities across firms.

The literature on the link between a firm's choice of patenting vs. secrecy and its subsequent performance is much thinner. An exception is Hussinger (2006), who investigates the impact of this choice on innovative performance, measured as the share of sales due to new products. She also uses the MIP in combination with patent filings at the German Patent and Trademark Office, restricting the sample to R&D-performing firms that report a product innovation. Hussinger finds patenting but not secrecy to be associated in a statistically significant and positive way with a firm's sales due to new products.

3. Data

The dataset used in our analysis consists of four components, which are all linked by a unique enterprise business register number:[7]

1. Business Structure Database (BSD);

[7] We conduct the analysis at the 'enterprise' level where an enterprise comprises all legal units under common control. The patent and trademark data is available only at the enterprise level which motivates us for consistency to conduct our analysis at the enterprise level.

2. UK Community Innovation Surveys (CIS) 3, 4, and 5;
3. UK and EPO patent data;
4. UK and Community (OHIM) trademark data.

The individual components are described in more detail in an Online Appendix.

The linked dataset is a firm-level panel that contains detailed information on firm characteristics, innovative activities as well as patent filings over the 9-year period 1998-2006. Due to the stratified nature of the sampling of the CIS data and a changing sampling frame over time, the panel is highly unbalanced.

Because each CIS refers to several years (CIS 3 to 1998-2000, CIS 4 to 2002-2004 and CIS 5 to 2004-2006), we collapse the panel to three time periods which cover the entire period 1998-2006 (with the exception of 2001).[8] This means that we look at patenting decisions any time over the three-year reference period of the CIS. Given the nature of the CIS, it is impossible to establish a closer link between an observed patenting decision in a given year and the reported underlying innovative activity. Because of this, our analysis is primarily cross-sectional and describes the general relationship between innovating and patenting behaviour across firms.

Table 1 shows the panel structure of the data, first for all firms matched to the CIS and then for the innovating sample we use in the subsequent analysis.[9] The shaded rectangles indicate the availability of data and it is easy to see that most firms were sampled only once. Only 485 firms have been sampled in all three CIS waves. The largest overlap between CIS waves exists for CIS 4 and 5 with a total of 5,136 firms. Overall, only one quarter of the sample firms appear in at least two CIS waves (and only 17% for the innovating subsample).[10]

[8] All continuous variables from the BSD are averaged over each of the three CIS reporting periods, whereas we use the maximum value for discrete variables from the BSD and the registered IP data. This implies, for example, that the patent dummy variable measures whether a firm has taken out at least one patent during a three-year CIS reference period.

[9] The table omits a few observations that were missing key variables such as employment.

[10] Although the CIS panel has relatively little overlap, for economic data from the BSD we have considerably more overlap, which allows us to compute employment growth over the whole period, for example. Note that for our analysis, we restrict the data to sectors that have been sampled in all three CIS waves, i.e., we exclude retail trade (SIC 52), hotels & restaurants (SIC 55), motion picture and video activities (SIC 921) and radio and television activities (SIC 922).

Table A1 in the Appendix shows the distribution of observations across sectors for the full CIS sample and for the firms in our innovation sample. The population sector shares shown in the third column of Table A1 have been produced using sampling weights to account for the stratified nature of the CIS samples. Because the sample stratification is largely by firm size, sectors with large firms are overweighted in our sample (that is, chemicals, food and beverages, high-tech metals and machinery, transportation, and manufacturing in general) and those with more small firms underweighted (business and computer services, R&D services, trade).

4. Descriptive analysis

This section provides descriptive evidence of the patenting activities of firms, looking at how patenting differs as a function of firms' underlying innovative activities and of the importance that firms attribute to different knowledge appropriation mechanisms. We also look at the relation between a firm's patenting decision and its innovative performance in terms of the sales of new products.

Table 2 shows the number of observations in our broad sample of firms that do any kind of R&D or that introduce new products and/or processes during the relevant three-year period. Here R&D is defined as either internal or external spending, the purchase of new hardware or software related to innovation, or spending on training, design, or marketing related to innovation.[11] The table shows that almost two-thirds of the firms undertake some kind of R&D-related spending and one-third have an innovation. In fact, very few firms in our sample innovate without spending on some kind of R&D.

The next three columns of the table show the numbers and shares of patenting firms in the large sample, and population shares, weighted using sampling weights to account for the stratified sampling of the CIS. Only 1.6% of the population of registered firms patent, whereas 2.9% of our sample does, again reflecting the slight up-weighting of larger firms. The figure is almost twice as large for manufacturing (5.9%) and lower for the Knowledge-intensive business sectors (1.7%). Firms that both innovate and spend

[11] Later in the paper, when we use R&D expenditure, it covers only actual spending on R&D for consistency with earlier work, and because coverage for the full set of innovation expenditures is relatively weak.

on R&D are roughly twice as likely to patent. If we look at the unweighted shares, we see that the largest share of patenting firms is found in the manufacturing sector for firms that conduct R&D and report an innovation (10.7%). Although there is a small number of observations where a firm has applied for a patent even though it has not innovated during the past three years, the share of innovating firms that patent is over five times that for non-innovating firms (645/10345 = 6.2% versus 240/20161 = 1.2%). In order to focus our attention on firms that have the potential to patent, the subsequent analysis in this paper is performed on the 10,345 firm-year observations shown in Table 2, those firms that introduced a product or process that was new to the firm or the market during the preceding three years.[12]

As discussed in the introduction, even when focusing our attention on innovative firms, there may still be important differences across the types of innovation. Table 3 distinguishes between the four types of innovations reported in the CIS: (i) product innovation new to the market, (ii) process innovation new to the market, (iii) product innovation new to the firm, and (iv) process innovation new to the firm. The largest share of innovators reports product innovations new to the market or process innovations new to the firm. However, firms with product innovations that are new to the market are considerably more likely to patent (conditional on conducting R&D). In particular firms that report a product innovation that is new to the market are about twice as likely to patent as firms that report a process innovation that is new to the market. These findings support both the view that product innovations that are generally novel are more likely to be based on a patentable invention and that process inventions are easier to keep secret and therefore less likely to be patented.[13]

Figure 1 shows the CIS answers with regard to the importance of the various IP protection mechanisms for our sample of innovating firms. Firms were asked in the CIS to evaluate the importance of the different mechanisms on a Likert scale between 0 and

[12] The actual estimation sample consists of 10,093 observations, as we lose a few observations (about 2%) because of missing or invalid data on the control variables.

[13] The table also suggests that a small share of innovating firms patents despite reporting only innovations new to the firm. This may suggest that firms file patent applications despite a low likelihood of passing the novelty and inventive step thresholds. It is also possible that a patent was filed on an invention that is not yet incorporated into a product. However, due to the nature of our data, we cannot establish a link between a reported innovation and the observed patent application to investigate this further.

3, where 0 means a firm does not use this type of protection mechanism whereas 3 means that it represents a 'very important' mechanism for the firm. The figure shows the share of firms that rate each type of IP mechanism as of medium or high importance. As would be expected, the share of firms regarding any of the registered IP rights (registered designs, trademarks, patents) as important is substantially larger for patenting than for non-patenting firms.[14] In contrast, patenting and non-patenting firms that are innovators rate informal IP mechanisms about the same. The results for registered IP suggest that if a firm patents, it is also more likely to think that other forms of registered IP are important. At the same time, patenting does not diminish the importance of informal IP protection, suggesting that firms may tend to use both mechanisms, possibly for different purposes.

Figure 2 provides evidence of the association of a firm's innovative activity and its share in sales due to product innovation, which can be considered as a measure of a firm's innovative performance. For ease of illustration, in Fig. 2, we have discretised firms' sales distribution into four size bands (0%; more than 0% and less than 10%; between 10% and less than 25%; and 25% and above). When looking at innovations that are 'new to the firm,' we do not see any strong pattern in the distribution of firms across turnover bands. Firms appear to be distributed similarly across turnover size bands independently of how highly they rank patents or secrecy. This suggests that there is little correlation between a firm's innovative performance in terms of turnover due to innovative products that are merely 'new to the firm' and the importance the firm attaches to the different protection mechanisms.

However, the data look different for innovations that are 'new to the market,' even though the average shares are approximately the same as those for 'new to the firm' sales. Firms that attach high importance to patents and/or secrecy also have a nonzero share of innovative sales. For example, only 25% of firms that have no turnover due to a product innovation that is 'new to the market' indicate heavy use of patents, whereas about 40% of firms with some innovative sales report heavy reliance on patents. The difference is similar with regard to the use of secrecy (44% in the 0% turnover category and about 62% in other categories). Overall, this suggests that firms that regard patents

[14] See also Table A2 in the Appendix.

and/or secrecy as important, and that have a product innovation that is 'new to the market' (i.e., high 'quality' invention), outperform (in terms of innovative sales share) firms that have such an innovation but do not use patents and/or secrecy. It also highlights the fact that although both secrecy and patents are used to protect inventions, even firms with innovative products new to the market seem to prefer secrecy to patents.

5. Empirical Analysis

Our empirical analysis explores three relationships: 1) the determinants of a firm's preference for formal over informal IP protection; 2) the determinants of the actual patenting decision; and 3) the implications of these preferences and decisions for firm performance.

We limit the regression samples to firms that report a product and/or process innovation during the CIS reference period in order to ensure that in principle all firms face a decision of how to protect their innovation. To account for the type and to some degree also for the 'quality' of inventions, we also include information on whether an innovation is new to the market or new to the firm. In the case where a firm patents its invention, we are also able to use some patent indicators that have been shown to be correlated with invention value.

The first equation we estimate is the following:

$$\begin{aligned} rel\_ip_{ic} = a + b_1 prodnM_{ic} + b_2 prodnF_{ic} + b_3 procnM_{ic} + b_4 procnF_{ic} \\ + gX_{ic} + f\, fip_{jc} + q iip_{jc} + d_c + m_j + e_{ic} \end{aligned} \quad (1)$$

where i denotes a firm, c denotes a CIS wave, and j denotes a sector. rel_ip_{ic} is a variable that measures the importance of one IP mechanism relative to another, following Arundel (2001), who suggested using the difference between the importance attributed to patents and secrecy. While levels may be difficult to compare at the firm-level, differences should be internally consistent. We consider two definitions of the relative importance variable: the difference between the formal IP and informal IP ratings and the difference between the patent and secrecy ratings. The former variable is roughly continuous, since the formal and informal IP measures are averages over a set of ratings and we use ordinary least squares for estimation. The latter variable takes on only seven integer values (-3, -2, -1, 0, 1, 2, 3) and we use ordered probit estimation when it is the dependent variable. The variables $prodnM_{ic}$ and $procnM_{ic}$ denote product and process innovations that are new to the market and variables $prodnF_{ic}$ and $procnF_{ic}$ denote product and process innovations that are new to the firm. Differences in the estimates associated with product innovations new to the market may arise if product inventions are more likely to represent patentable subject matter than process innovations. In addition, the variable that indicates whether a product innovation is 'new to the market' may also capture the costs associated with disclosing the invention to the public. If firms consider inventions characterised by a larger inventive step to be more valuable, then disclosing the information through a patent application may be less desirable to the firm and hence a firm may be more likely to opt for secrecy (Anton and Yao, 2004). Variable fip_{ic} represents firms' perception of the importance of protection mechanisms in the form of formal intellectual property (registered design, trademark, patent, and copyright) at the SIC 3-digit sector level. iip_{ic} denotes the importance firms in the 3-digit sector attribute to informal protection mechanisms including secrecy, lead time, and complexity. These variables are constructed as simple averages across all firms in an SIC 3-digit industry.

X_{ic} is a vector of firm-level characteristics including R&D intensity and a dummy variable for firms with no R&D, firm age, size, size squared, whether the firm is foreign-owned, whether the firm is a member of a group, and whether the firm exports. We also include a dummy variable that indicates whether the firm reported financial constraints to its innovative activity.

The second equation we estimate is an equation for the probability a firm applies for a UK/EPO patent during the relevant period:

$$p_{ic} \sim \Phi\begin{pmatrix} \alpha + \beta_1 prodnM_{ic} + \beta_2 prodnF_{ic} + \beta_3 procnM_{ic} + \beta_4 procnF_{ic} \\ +\gamma X_{ic} + \phi fip_{jc} + \theta iip_{jc} + \delta_c + \mu_j + \varepsilon_{ic} \end{pmatrix} \quad (2)$$

p_{ic} denotes firm i's actual patenting decision (firm i is in sector j and CIS wave c). This means that we reduce a firm´s decision to a binary choice, either the firm decides to patent or not.[15] The fact that information reported in the CIS refers to a 3-year period means that we relate patent applications anytime during the 3-year period to whether a firm reports an innovation over the same period. *Φ(.)* is the normal distribution and we use a simple probit model for estimation. The independent variables are the same as those used in the first model (we add a dummy for either British or Community (OHIM) trademark ownership). Since we condition the sample on firms reporting a product and/or process innovation, we may interpret the decision not to patent as a decision to use some alternative mechanism to protect a given invention.

Existing survey evidence suggests that firms tend to use only some of their patents (Giuri et al., 2007), which means that the decision to patent *per se* may not be informative about its effect on performance. To gain more insight, in a third step, we analyse directly the relationship between a firm's observed decision to patent and its (innovative) performance. As performance measures, we use (a) the share of a firm's turnover that is due to innovations, with separate variables for innovations that are 'new to the firm' and 'new to the market.' This allows us to distinguish between the effect of patenting on a firm's sales based on imitation ('new to the firm') and innovation ('new to the market'). In addition, we also use (b) firm growth measured by employment as a performance measure.[16] The model specification is thus:

$$perform_{ic} = \alpha + \beta p_{ic} + \phi \, fip_{jc} + \theta iip_{jc} + \gamma X_{ic} + \delta_c + \mu_j + \varepsilon_{ic} \qquad (3)$$

where *perform* is the share of sales from products new to the market, the share of sales from products new to the firm, or employment growth. In Equation (3), the main object of interest is the variable p_{ic} which indicates whether a firm has applied for a patent during the reference period. Most of the other variables are as in Equation (1), with the addition of an indicator of whether the firm also owns trademarks. We drop the

[15] We are primarily interested in whether a firm applies for a patent at all and less in its patenting intensity which is why we collapse the number of patent applications to a binary variable. However, we also obtained results for specification (2) using patent counts as the dependent variable. The results are very similar to those reported in Table 5 and are available upon request.

[16] We also investigated labour productivity as performance measures. However, labour productivity is only available for firms that are included in the ARD2. This means that the sample is considerably smaller and we therefore prefer to rely on the CIS-based turnover performance measure and employment growth computed using the BSD.

financial constraints indicator, on the grounds that they should not affect the performance relationship, but only the choice of inputs.

6. Results

In this section we discuss the results from estimating Equations 1-3. Descriptive statistics for our regression sample are provided in online Appendix Tables A3 (univariate) and A4 (correlations).

6.1 The relative importance of formal and informal IP

Table 4 shows the results for the specification of the model in Equation (1). Columns (1) to (3) show results for the relative importance of formal versus informal IP and column (4) compares patents to secrecy. We include time dummies in all specifications and sector dummies in columns (2) to (4).

With respect to the key variables, the results for formal vs. informal and patents vs. secrecy are essentially the same. Larger firms are more likely to prefer formal IP to informal IP, but not patents to secrecy. In the latter case, financial constraints appear to be more important than size. All types of innovation are associated with a slight preference for informal methods to formal methods of protection, something which we also saw in Figs 1 and 2. One explanation may be that informal methods become relatively more important when a firm is innovative, reducing the gap between formal and informal methods (and leading to a fall in the relative importance of formal vs. informal methods).

An interesting result in column (3) is that the coefficients on the corresponding sector-level variables are approximately equal to one and opposite in sign. This implies that a firm's rating of relative importance moves one for one with the 3 digit sector level rating of relative importance (within two digit industries, which have been controlled for). Judging from the improvement in the small explanatory power of this regression, the sector level preferences are one of the more important drivers of the firm level preference.

The results for the R&D variables are somewhat puzzling. About half of the firms have R&D on the BSD. Those that do not strongly prefer informal to formal IP and secrecy to patents. However, it is also true that for those that report R&D, higher R&D intensity is also associated with a preference for informal IP protection over formal. This may reflect the fact that such firms are generally newer and smaller technology-intensive firms facing more uncertainty over the success of their inventions and innovations. Although age and size are controlled for, there is variation even among young small firms which is reflected in this coefficient.

6.2 The decision to patent

In Table 5 we show results for the probit estimation of equation (2), the decision to patent. The first column presents results without sector dummies, and the remaining three columns include them. Patenting firms are larger, slightly more likely to be exporting, more likely to be a member of a group, but slightly less likely to be foreign-owned, which may reflect to some extent a tendency for foreign-owned UK enterprises to file patents under their parent name (and therefore not be matched to our sample). They are also more likely to use trademarks.

The regressions show strongly that patenting is associated with new-to-the-market innovation and not with new-to-the-firm innovation (except when the sector dummies are left out). We view this as validation of the 'new-to-the-market' concept. Although it is a long way from a 'novel' invention (one of the statutory requirements for a patent) to a product 'new-to-the-market,' these regressions indicate that the two are related, with such a product innovation essentially doubling the probability that a firm will patent.

In the previous table, we found that a firm's perception of the relative importance of formal over informal IP was influenced by the sectoral perception, but this relationship does not translate to the patenting decision of the firm. The sectoral rating of the importance of formal vs. informal IP is not significant, whereas firms that rate formal IP highly are indeed more likely to patent.

Our preliminary conclusions from this investigation into the reasons for the low patenting rate among UK firms are the following. First, only one third of firms have any innovations during a three-year period. Second, only about half of those have innovations new to the market. So at most, we might expect about 18 % of the firms to patent. In addition, size plays an important role, as we can see in Figs 3 and 4. Figure 3 uses the regression results in Table 4 to show the predicted patenting propensity as a function of size for four types of firms in the metals and machinery sector: non-innovating and non-R&D-doing, innovating and non-R&D-doing, new-to-the-firm innovating and R&D-doing, and new-to-the-market innovating and R&D-doing. As expected, there are huge differences in expected patenting propensities for these four types of firms. But it is important to observe that almost all (about 90-95%) of our firms lie in the region below 500 employees, and that the median firm has about 50 employees. At that size, all but the new to the market innovators have patenting propensities less than 10%. So size explains a lot.[17]

Figure 4 shows that another explanation is differences across sectors, as expected. It shows the patenting propensity-size distribution for a new-to-the-market innovator that does R&D in five different sectors, ranging from the least patent-intensive (financial intermediation firms) to the most (R&D services firms). At the median firm size, the propensities range from 1% to almost 50%. In fact, the pseudo R-squared from a regression of patenting on size, sector, and survey year alone is 0.18; adding the additional variables to the model does not improve its prediction accuracy over this simple regression, even though they are significant in some cases.

A final explanation we have uncovered is in the attitudes of the firms surveyed by the CIS. On average, all types of innovators, including new-to-the-market innovators, rate informal means of protection, especially secrecy, as a more important IP protection mechanism than patents, which suggests that they are likely to place more reliance on that method of protection. Those firms that do choose to patent also tend to have trademarks, suggesting that some firms like use of formal IP of all kinds, whereas others do not.

6.3 Innovative performance

This section analyses directly the relationship between a firm's choice to patent an invention (or maintaining it as a secret) and its innovative performance, conditional on the firm having some kind of innovation. We show results for the analysis of the relation

[17] This confirms earlier findings by Rogers *et al.* (2007a), in which the authors found a substantially larger share of firms in the large-firm category to patent than among SMEs. They also found patenting companies in the large-firm category to file considerably more applications than firms in the small- and medium-size category.

between two measures of innovative performance (sales of products new to the firm and sales of products new to the market) and a firm's decision to patent. Following the literature (Mairesse and Mohnen 2010), we transform the sales share with a logit transform so that the dependent variable is quasi-normally distributed and the coefficients of the regression are close to elasticities or semi-elasticities. To see this, note that the estimated coefficient associated with the variable X in such a regression is the following:

$$\beta = \frac{\partial \log[s/(1-s)]}{\partial X}$$

where s is the sales share. The semi-elasticity of s with respect to X is therefore:

$$\frac{\partial \log s}{\partial X} = \beta(1-s)$$

which is approximately equal to β when s is small, and declines towards zero as s becomes large.

Columns (1) and (2) of Table 6 show the results when we consider only product innovations that are 'new to the market,' which we consider to be 'true' innovations that could in principle be patentable. The most salient finding is the large positive coefficient associated with the patent dummy variable, which suggests a strong positive association between a firm´s decision to rely on a patent and its performance in terms of share in turnover due to an innovation. Having applied for a patent during the period increases the share of turnover from new products by about 50% at the mean share of 8%. Clearly, this does not imply any causal effect of patents on innovative sales, as we cannot rule out potential reverse causality or other unobservables correlated with patenting driving this effect. However the use of patents suggests that the firm has a more marketable innovation and is operating in a market segment where formal IP protection is important. Also having trademarks has an additional positive impact on new-to-the-market innovative sales.

Columns (3) and (4) of Table 6 show the results when we consider innovative sales from product innovations that are 'new to the firm.' These are likely to be imitations of existing innovations and therefore far less patentable than innovations that are considered to be 'new to the market.' This is reflected in the results shown -- the patenting dummy is not statistically significant in either of the specifications shown, nor is the trademark dummy or the sector-level importance of formal IP. This means that the share of turnover generated with products that are derived from innovations that are only 'new to the firm' is not associated in a statistically significant way with a firm's observed patenting behaviour.

In contrast, most of the coefficients associated with the other regressors in columns (3) and (4) display the same signs and similar magnitudes as in the first two columns of Table 6, with two exceptions: R&D intensity and exports. R&D intensity is negatively associated with new-to-the market-sales but not with new-to-the-firm sales. This may be because the most R&D-intensive firms do not produce products, but instead license their results to producing firms. In contrast, exporting firms have approximately 10% higher share of sales of products new to the firm, but about the same share of sales of products new to the market, suggesting that they are more likely to be engaged in exploiting existing innovations over a broader market rather than creating new ones.

6.4 Growth performance

The last two columns of Table 6 use employment growth as an indicator of firm performance.[18] Employment growth regressions have a long history and raise a number of econometric specification issues; for a review of these, see Hall (1987). That paper explores the role of measurement error and sample selection in estimating the growth-initial size relationship and reports two main findings: 1) measurement error in employment appears to introduce little bias in the size coefficient and 2) there did appear to be a sample selection effect whereby smaller firms were more likely to exit, but this was confounded with size-related heteroskedasticity and possibly nonlinearity in the relationship. The conclusion was that attrition bias was likely to be rather small. Since here we are using a similar sample of UK firms and we are mainly concerned with the influence of the IP-related variables on growth, we control for size but do not

[18] Rogers *et al.* (2007b) analyse the association between firms' patenting decision on subsequent growth for the population of SMEs in the UK. Due to data limitations they are constrained to using growth in total assets and turnover as performance measures. Their results also suggest no statistically significant correlation between a firm's patenting activity and its asset and turnover growth

investigate measurement error and attrition biases, on the grounds that they are likely to be small.

We rely on the BSD data to construct the employment growth measure as the average annual growth rate over the number of years available for each firm between 1998 and 2006. We show the results of regressions of the growth rate on whether the firm has a patent, whether it has a trademark, and the sectoral importance of formal and informal IP as well as the controls, time, and sector dummies. All variables are measured at the beginning of the period (either 1998 or later if the firm enters the sample later). The results suggest a positive association between patenting and employment growth, but one that is statistically insignificant. Firms with patents have growth rates that are on average 12% (in level) above those without patents, controlling for sector, size, age, R&D, exporting, foreign ownership, and group membership.

Consistently with the new-to-market innovation performance results, we find that older firms grow more slowly and group members grow faster. In contrast to those results, exporting firms exhibit worse employment growth. Controlling for a firm's own patenting, the sectoral importance of formal and informal IP is not associated with growth, unlike the case of innovative sales.

Our final exploration in the last column also looks at whether several patent indicators that are known to be associated with patent value have any relationship to employment growth. That is, if we control for the quality of the inventions that are patented as well as the simple fact that at least one patent was applied for, can we see any relationship. The indicators we use are the average number of distinct classes (IPCs) per patent, the number of forward citations received per patent, the number of backward citations made per patent, and the number of citations to the non-patent literature made per patent, all in logs. Unfortunately none of them enter significantly, and the net effect of these variables is to weaken the coefficient on the simple patent dummy, with little impact on the other variables in the model. Our conclusion is that we may have too small a sample of patenting firms (recall that only 6% of innovating firms patent) to obtain much precision using these indicators.

6.5 Sectoral differences

In Tables 7 and 8 we look at how our estimates differ across two major sectors involved in innovation: a traditional R&D-intensive sector, manufacturing, and a service sector, that relies less on R&D but innovates heavily, Knowledge-Intensive Business Services (KIBS), which consists of business services (2003 UK SIC 71 and 74), computer services (SIC 72) and R&D services (SIC 73). The contrast is of interest for two reasons: first, because the innovation process in the two sectors is quite different, with manufacturing being more 'technological' in general, and second, because the KIBS sector is growing relative to manufacturing.[19] 11.5% of the observations in the manufacturing sample have a patent, whereas only 3.9% of the KIBS sector observations have a patent.

The first two columns of Table 7 present results for the ordered probit regression with the relative importance of patents vs. secrecy as a dependent variable. Innovating firms in the two sectors clearly weight the importance of patents vs. secrecy differently: manufacturing firms have a slight positive preference for patents if they are new-to-the-market product innovators, but prefer secrecy if they are process innovators (as expected). On the other hand, innovating firms in KIBS strongly prefer secrecy to patents. This finding also holds for formal IP vs. informal IP in general (not shown). None of the other firm characteristics seem to have an influence on their rating of patents vs. secrecy in both sectors, with the exception of firm age and R&D intensity in manufacturing.

The last two columns present the patenting probability estimates for the two sectors. In the manufacturing sector innovating firms (other than mere new-to-the-firm process innovators) are more likely to patent, whereas only new-to-the-market product innovation is associated with patenting in KIBS. For both manufacturing and KIBS, being in a sector that rates formal IP protection as important is associated with patenting, as is size, being a member of a group, and financial constraints (negatively). Thus the main contrast between manufacturing and KIBS is that patenting is slightly more strongly associated with innovation in the former, whereas it is more strongly associated with exporting in the latter. This suggests some heterogeneity within both sectors – large

[19] Between 2005 and 2010, manufacturing employment in the UK declined 37%, while employment in Professional, scientific, and technical services grew 32% (Wilson and Homendiou, 2012, Table 3.4).

exporting firms that are in a group and not financially constrained use patents, whereas the other smaller firms are much less likely to.

Table 8 presents the performance regressions for the two sectors. First, we note that the strongest and most stable relationship is that older firms have lower innovative sales and lower growth, in both sectors as in the aggregate. Having a patent application is strongly associated with the new-to-the-market innovation sales share, but in the case of KIBS, it is strongly negative for the new-to-the-firm innovative sales share. We are not sure how to interpret this, although it may be related to variation in the level of vertical integration in these kinds of service firms. That is, research-oriented firms that patent may not have much in the way of innovative sales, since they supply under contract to other firms.

The growth rate regressions for manufacturing are similar to those for all firms, with an insignificant positive association with patenting and more strongly positive association with having trademarks. The coefficients on size and size squared imply that growth falls with firm size until around 300 employees and then increases. In addition, the coefficients of interest in the KIBS regression have very large standard errors, suggesting weak identification. An interesting result is that the relative importance of formal vs. informal IP in the 3-digit sector is strongly associated with employment growth, even in the presence of the 2-digit sector dummies. It is possible that the attitudes toward IP are better predictors in this sector than actual patenting and trademarking because there are relatively few firms that make use of these formal IP mechanisms yet, although there may be more in the future. Another alternative is that patenting and trademarking are somewhat undercounted due to the difficulties of matching the newer and younger firms in these sectors to the IP data.

7. Conclusion

This paper provides an analysis of the determinants of a firm´s patenting decision and assesses the potential implications of the choice on its performance measured as innovative sales and as employment growth. The analysis relies on a new integrated dataset that combines a range of data sources into a panel at the enterprise level. Our findings suggest the following conclusions.

Determinants of a firm´s choice of IP protection

Our descriptive analysis shows about one third of UK firms report any form of innovation. Strikingly, we find that only 3% of firms in our sample patent and that even among firms that conduct R&D, only 4% patent. In particular, the share of patenting firms is much lower than what one might expect given that around 20% of firms that invest in R&D report product innovations.

When we investigated the determinants of patenting versus not patenting for innovative firms, we found that most of the predictor variables confirmed prior intuition: patentees are more likely to be product innovators rather than process innovators, more likely to also use trademarks, and they are larger, slightly more likely to export, and to be part of a business group.

What then explains the fact that so few of the firms patent, even if we restrict ourselves to new to the market product innovators that do R&D? One possible reason is that the samples we are using contain a large number of smaller firms (<250 employees) who may find use of the formal IP system simply too costly. This hypothesis is weakly supported by the small negative coefficients on the presence of financial constraints in both the importance of formal IP vs. informal IP and the patent propensity regressions. Certainly size is a very important predictor in our patenting propensity regressions and coupled with the skew size distribution for firms, this can explain the low patenting rate. However, looking at the large sample (which includes sectors that generally do not have patentable inventions), we have seen in earlier work (Hall et al. 2012b) that almost half of the large firms do not use formal or informal IP either. Because firms that use one IP mechanism are more likely to use another, another possibility is that firms have a 'propensity' to use or not use IP, and that the problem is lack of familiarity with the system and suboptimal behaviour on the part of some firms.

A final (and perhaps the most likely) explanation is that the use of any IP protection mechanism costs time and money and most firms find that the benefits do not exceed the costs, especially in the case of patents.[20] However, our findings on performance call

[20] The costs of patenting do not only involve the direct financial costs of preparing and prosecuting a filing (or paying for specialized counsel), but also indirect costs in form of for example management time. In addition, patents need to be enforced, which requires the monitoring of possible infringement and taking legal action in case infringement is detected. As documented by Helmers and McDonagh (2012), patent

this explanation into question, at least for some firms. The large positive association between patenting and innovative sales suggests that there could be non-patenting firms out there that would benefit from using patents or other forms of IP protection.

The use of IP protections and (innovative) performance

The results on innovation performance suggest that patented innovations are more successful in promoting innovative sales. However, because we do not know whether performance and patenting are both driven by the unobservable quality of the firm's innovation or by the quality of the firm itself, it is not possible to make a causal inference based on our analysis that patenting any innovation will lead to better innovative sales performance. In contrast, we do not find any statistically significant association between patenting and employment growth.

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litigation in the UK, before the Patents Court, is extremely costly, with costs varying between GBP 1 and 6 million for cases heard by the court between 2000 and 2008.

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Figures

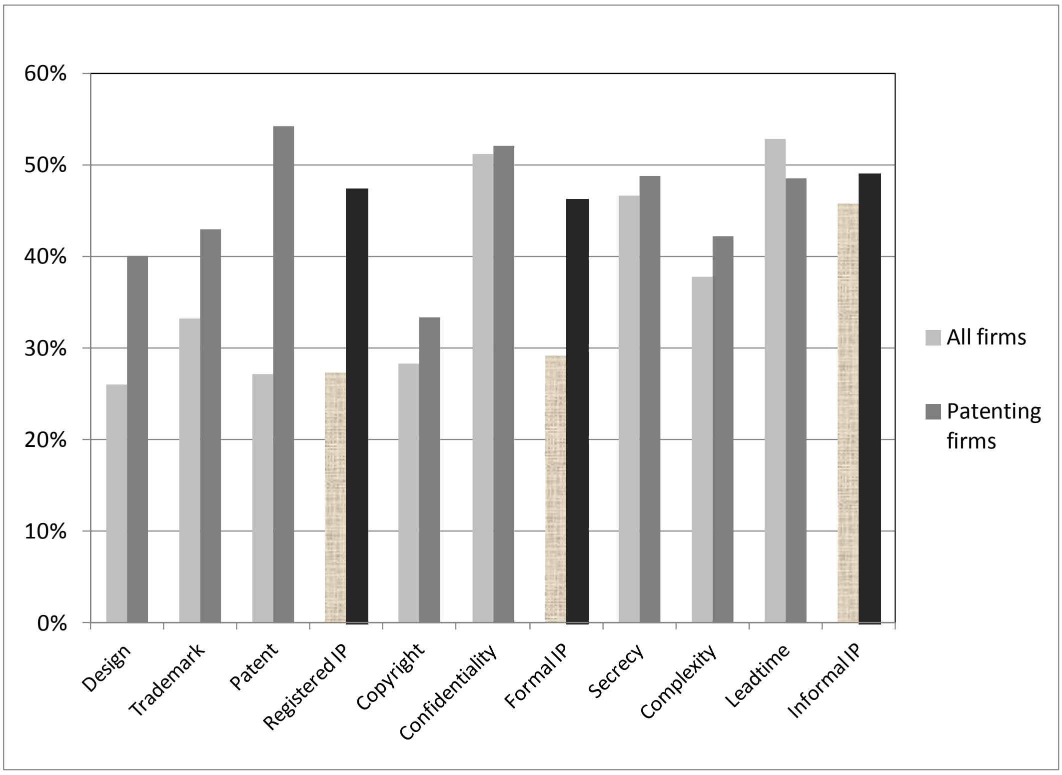

Fig. 1: Share of innovating firms rating different types of IP protection as medium or highly important

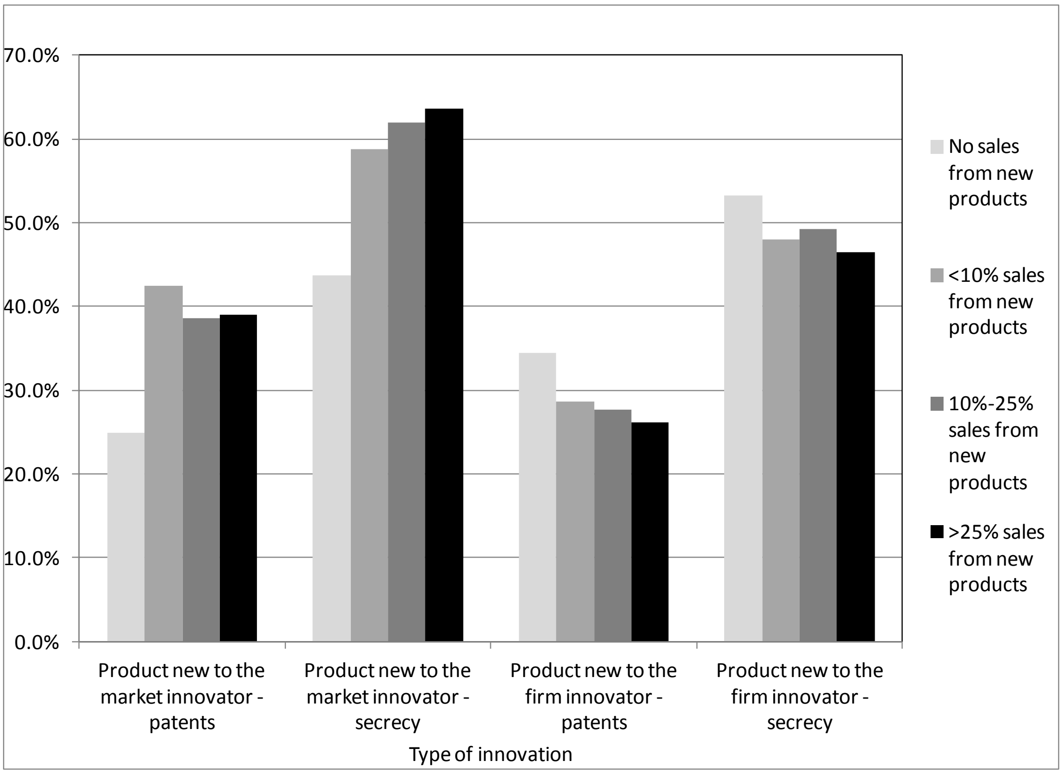

Fig. 2: Importance of patents and secrecy to product innovators

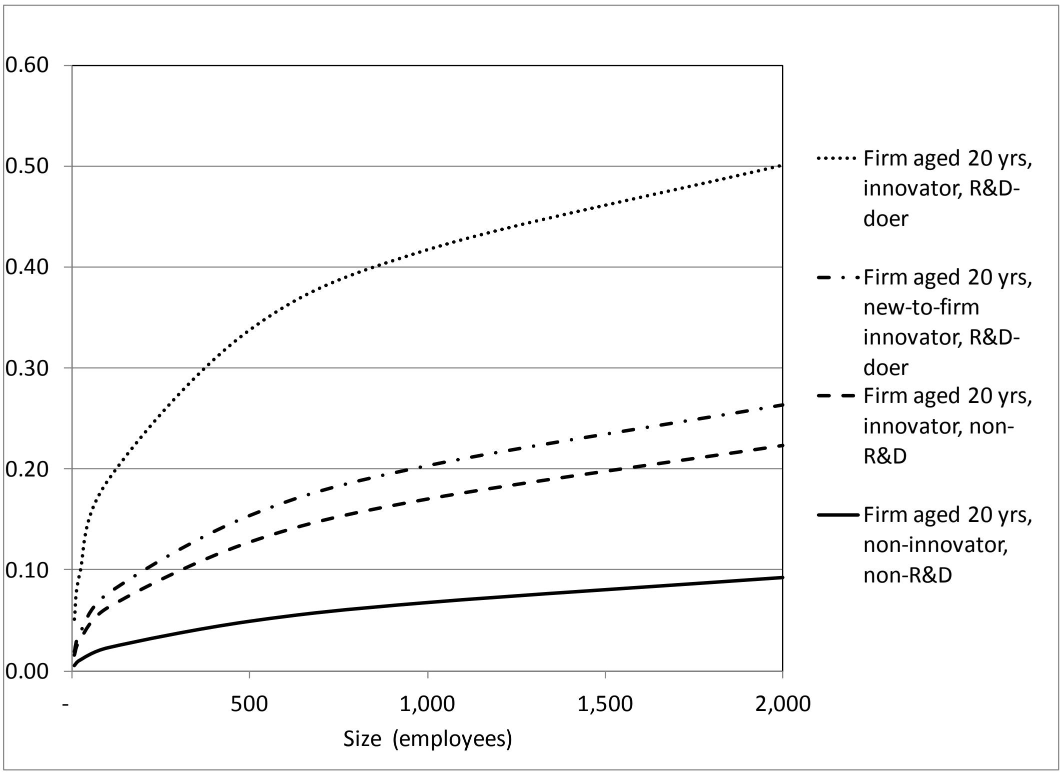

Fig. 3: Probability of patenting – metals and machinery sector

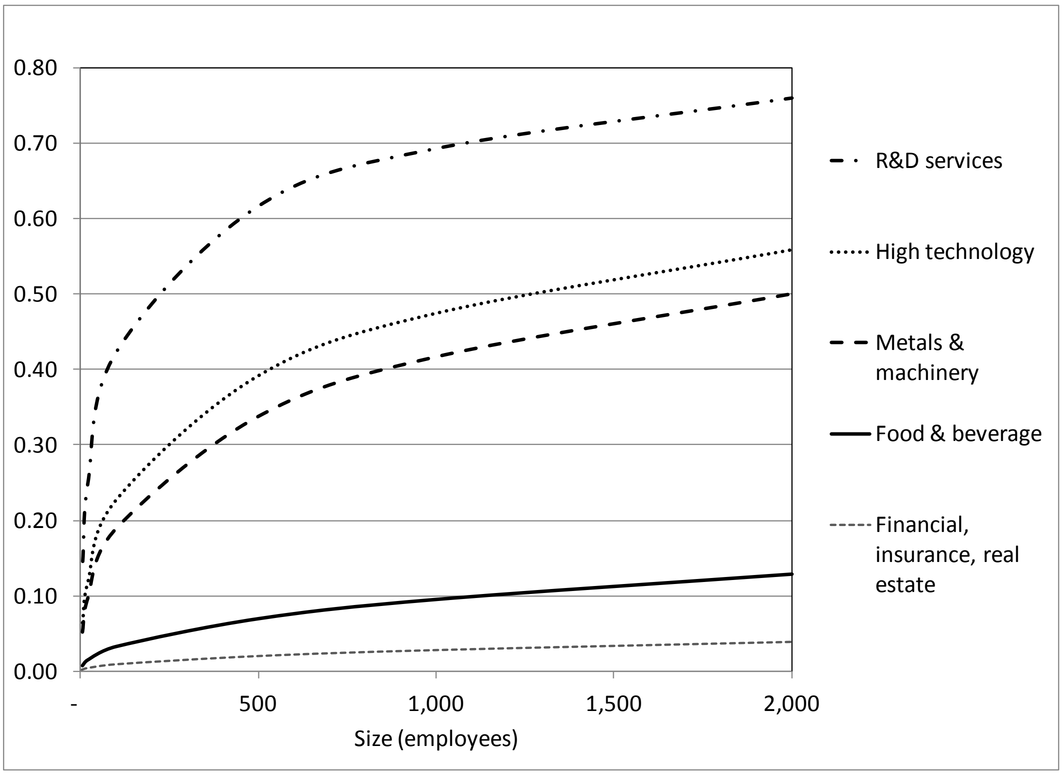

Fig. 4: Probability of patenting – Innovating, R&D-doing firms aged 20 years

Tables

Table 1

Panel structure

Number of firms	Share (%)	Sample firms*	Share (%)	CIS 3	CIS 4	CIS 5
485	2.0%	98	1.1%	X	X	X
396	1.7%	148	1.7%	X	X	
5,136	21.6%	1,098	12.8%		X	X
214	0.9%	74	0.9%	X		X
5,905	24.8%	1,595	18.6%	X		
5,929	24.9%	3,243	37.8%		X	
5,725	24.1%	2,321	27.1%			X
23,790		**8,577**				

Note: X indicates where data are available.

*The sample of innovating firms, cleaned, used for analysis

Table 2
Share of patenting firms (sample relative to the population)

	All sectors				Manufacturing			KIBS**		
	All	*Has UK or EPO patent*	*Share with patents*	*Pop share with patents*	*All*	*Has UK or EPO patent*	*Share with patents*	*All*	*Has UK or EPO patent*	*Share with patents*
Total	30506	885	2.9%	1.6%	11151	662	5.9%	8446	146	1.7%
Does R&D	18610	747	4.0%	2.3%	7666	587	7.7%	5115	131	2.6%
Innovates	10345	645	6.2%	3.9%	4951	*	*	2723	*	*
No R&D or innovation	11018	113	1.0%	0.6%	3191	73	2.3%	3104	20	0.6%
R&D but no innovation	9143	127	1.4%	0.6%	3009	91	3.0%	2619	23	0.9%
Innovation but no R&D*	878	11	1.3%	1.3%	294	*	*	227	*	*
Does R&D and innovates	9467	634	6.7%	4.2%	4657	496	10.7%	2496	99	4.0%

*The cells with * are missing due to suppression of data due to confidentiality reasons.

** KIBS consists of business services including computing and R&D services.

Table 3

Types of innovation

	Innovators with			
	product	*process*	*product*	*process*
	new to the market		*new to the firm, but not the market*	
All firms	4015	1645	3095	4009
R&D doers	3797	1564	2893	3757
R&D doers who patent	433	178	107	216
	Sample share innovating			
All firms	13.2%	5.4%	10.1%	13.1%
R&D doers	20.4%	8.4%	15.5%	20.2%
R&D doers who patent	58.0%	23.8%	14.3%	28.9%
Note that a negligible number of firms patent but do not do R&D.	-	-	-	-

There are 31,722 firms in the sample, including non-innovators.

Table 4

The relative importance of formal vs. informal IP protection mechanisms (10,093 observations)

Dependent variable		*formal vs. informal*		*patents vs. secrecy*
		OLS		*Ordered probit*
Variable	(1)	(2)	(3)	(4)
Product innovation new to the market	-0.12 (0.02)***	-0.13 (0.02)***	-0.12 (0.02)***	-0.05 (0.03)*
Process innovation new to the market	-0.17 (0.02)***	-0.17 (0.02)***	-0.16 (0.02)***	-0.12 (0.03)***
Product innovation new to the firm	-0.06 (0.02)***	-0.06 (0.02)***	-0.06 (0.02)***	-0.07 (0.03)**
Process innovation new to the firm	-0.12 (0.02)***	-0.12 (0.02)***	-0.11 (0.02)***	-0.12 (0.02)***
Formal IP important in the 3-digit sector			1.26 (0.07)***	
Informal IP important in the 3-digit sector			-1.17 (0.07)***	
D (financial constraints)	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)	-0.06 (0.02)***
Log (R&D per employee)	-0.05 (0.01)***	-0.05 (0.01)***	-0.05 (0.01)***	-0.05 (0.01)***
D (no R&D)	-0.16 (0.04)***	-0.16 (0.04)***	-0.15 (0.04)***	-0.15 (0.06)***
Log age	0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	0.03 (0.02)*
Log employment	0.01 (0.01)	0.01 (0.01)***	0.01 (0.01)***	-0.02 (0.02)
Log employment squared	-0.00 (0.002)	-0.00 (0.002)	-0.00 (0.002)	-0.005 (0.003)
D (exports)	-0.05 (0.04)	-0.04 (0.04)	-0.04 (0.04)	-0.05 (0.05)
D (member of a group)	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)	0.04 (0.03)
D (foreign-owned)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	0.03 (0.03)
15 sector dummies	No	Yes	Yes	Yes
Standard error	0.790	0.789	0.777	
R-squared	0.023	0.028	0.058	0.013

Heteroskedastic-consistent standard errors clustered on enterprise are shown in parentheses.
Period dummies for the three different CIS waves are included in all regressions.

Table 5
Probit estimation of the probability a firm patents
10,093 observations (8,577 enterprises)

	Marginal effects (s.e.)			
Variable	*(1)*	*(2)*	*(3)*	*(4)*
Product innovation new to the market	0.060 (0.006)***	0.047 (0.006)***	0.046 (0.006)***	0.033 (0.006)***
Process innovation new to the market	0.016 (0.006)***	0.015 (0.006)***	0.015 (0.006)***	0.013 (0.006)**
Product innovation new to the firm	0.017 (0.007)**	0.012 (0.007)	0.012 (0.007)*	0.011 (0.007)
Process innovation new to the firm	0.002 (0.005)	0.000 (0.005)	0.000 (0.005)	0.002 (0.005)
Formal IP important in 3-digit sector			-0.006 (0.018)	
Informal IP important in 3-digit sector			0.026 (0.017)	
Formal IP important to the firm				0.031 (0.003)***
Informal IP important to the firm				0.003 (0.003)
D (financial constraints)	-0.003 (0.005)	-0.007 (0.004)	-0.007 (0.004)	-0.015 (0.004)***
D (has trademarks)	0.084 (0.006)***	0.089 (0.006)***	0.089 (0.006)***	0.073 (0.005)***
Log (R&D per employee)	-0.005 (0.003)	-0.000 (0.003)	0.000 (0.003)	0.003 (0.003)
D (no R&D)	-0.029 (0.011)**	-0.012 (0.011)	-0.011 (0.011)	0.000 (0.010)
Log age	-0.001 (0.004)	-0.007 (0.004)*	-0.007 (0.004)*	-0.003 (0.004)
Log employment	0.008 (0.003)**	0.017 (0.004)***	0.017 (0.004)***	0.018 (0.004)***
Log employment squared	-0.000 (0.000)	0.001 (0.001)*	0.001 (0.001)**	0.002 (0.001)***
D (exports)	0.020 (0.008)**	0.009 (0.009)	0.009 (0.009)	0.009 (0.009)
D (member of a group)	0.035 (0.006)***	0.034 (0.005)***	0.034 (0.005)***	0.032 (0.005)***
D (foreign-owned)	-0.001 (0.005)	-0.009 (0.005)*	-0.009 (0.005)*	-0.010 (0.005)*
Sector dummies	no	yes	yes	yes
Share with dep var=1	0.064	0.064	0.064	0.064
Share correctly predicted	0.936	0.939	0.939	0.939
Share correctly predicted (dep var=1)	0.074	0.155	0.155	0.159
Share correctly predicted (dep var=0)	0.995	0.993	0.993	0.992

Heteroskedastic-consistent standard errors clustered on enterprise are shown in parentheses.
Period dummies for the three different CIS waves are included in all regressions.

Table 6: Performance regressions

Dependent variable	*Log (Share/(1-Share))*				*Average employment growth 1998-2006*	
	Sales share product new to the mkt		*Sales share product new to the firm*			
	(1)	(2)	(3)	(4)	(5)	(6)
D (has EPO or UK patent)	0.531 (0.082)***	0.518 (0.082)***	-0.025 (0.064)	-0.029 (0.064)	0.121 (0.078)	-0.194 (0.147)
D (has trademarks)	0.202 (0.064)***	0.181 (0.063)***	0.076 (0.054)	0.072 (0.055)	0.055 (0.054)	0.049 (0.054)
Formal IP important in the 3-digit sector		0.195 (0.139)		-0.045 (0.122)	-0.119 (0.119)	-0.120 (0.120)
Informal IP important in the 3-digit sector		0.317 (0.135)**		0.208 (0.119)*	0.071 (0.112)	0.062 (0.112)
Log (R&D per employee)	-0.091 (0.027)***	-0.085 (0.024)***	0.014 (0.022)	0.016 (0.022)	-0.007 (0.027)	-0.011 (0.027)
D (no R&D)	-0.238 (0.084)***	-0.214 (0.084)**	0.057 (0.073)	0.063 (0.073)	-0.077 (0.088)	-0.090 (0.087)
Log age	-0.225 (0.031)***	-0.222 (0.031)***	-0.220 (0.031)***	-0.220 (0.031)***	-0.412 (0.039)***	-0.412 (0.039)***
Log employment	-0.047 (0.028)*	-0.046 (0.028)	-0.021 (0.026)	-0.021 (0.026)	0.104 (0.037)***	0.084 (0.041)**
Log employment squared	0.010 (0.005)**	0.011 (0.005)**	0.009 (0.005)*	0.008 (0.005)	0.041 (0.009)***	0.037 (0.010)***
D (exports)	-0.082 (0.071)	-0.081 (0.071)	0.108 (0.029)***	0.108 (0.029)***	-0.241 (0.063)***	-0.249 (0.064)***
D (member of a group)	0.074 (0.044)*	0.061 (0.044)	0.091 (0.041)**	0.087 (0.041)**	0.115 (0.041)***	0.110 (0.041)***
D (foreign-owned)	0.080 (0.040)	0.073 (0.040)*	0.016 (0.037)	0.014 (0.037)	-0.038 (0.036)	-0.041 (0.036)
Log (average #IPCs per pat)						0.002 (0.126)
Log (backward cites per pat)						0.104 (0.080)
Log (forward cites per pat)						0.028 (0.098)
Log (NPL cites per pat)						0.176 (0.212)
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.054	0.059	0.135	0.135	0.075	0.076
Standard error	1.56	1.56	1.54	1.54	1.36	1.36
Observations	10,093	10,093	10,093	10,093	6,712	6,712

Heteroskedastic-consistent standard errors clustered on enterprise are shown in parentheses.

Period dummies for the three different CIS waves are included in all regressions.

Table 7

Patenting and its relative importance by broad sector

Dependent variable	*patents vs. secrecy*		*D (patent app during the period)*	
	Ordered probit coefficients		*Marginal effects (s.e.)*	
Variable	Manufacturing	KIBS	*Manufacturing*	*KIBS*
Product innovation new to the market	0.07 (0.04)*	-0.14 (0.06)**	0.05 (0.01)***	0.03 (0.01)***
Process innovation new to the market	-0.12 (0.05)**	-0.09 (0.06)	0.02 (0.01)*	0.00 (0.01)
Product innovation new to the firm	0.03 (0.04)	-0.15 (0.06)**	0.03 (0.01)*	0.01 (0.01)
Process innovation new to the firm	-0.09 (0.03)***	-0.18 (0.05)***	0.00 (0.01)	-0.00 (0.01)
Formal IP important to the firm			0.06 (0.005)***	0.03 (0.005)***
Informal IP important to the firm			-0.00 (0.01)	0.01 (0.00)*
D (financial constraints)	-0.03 (0.03)	-0.06 (0.04)	-0.03 (0.01)***	-0.01 (0.01)**
Log (R&D per employee)	-0.05 (0.02)**	-0.04 (0.03)	0.00 (0.00)	0.00 (0.00)
D (no R&D)	-0.18 (0.08)	-0.08 (0.12)	0.01 (0.02)	-0.01 (0.01)
Log age	0.06 (0.03)**	0.03 (0.03)	0.00 (0.01)	-0.00 (0.00)
Log employment	-0.00 (0.02)	-0.01 (0.05)	0.03 (0.01)***	0.01 (0.00)**
Log employment squared	-0.00 (0.00)	-0.00 (0.01)	0.00 (0.00)	0.002 (0.001)**
D (exports)	-0.06 (0.06)	0.05 (0.11)	0.01 (0.02)	0.05 (0.02)**
D (member of a group)	0.06 (0.04)	0.02 (0.06)	0.06 (0.01)***	0.02 (0.01)***
D (foreign-owned)	0.03 (0.04)	0.00 (0.06)	-0.02 (0.01)*	-0.01 (0.01)
R-squared	0.01	0.005		
Share with dep var=1			0.115	0.039
Share correctly predicted			0.906	0.962
Share correctly predicted (dep var=1)			0.210	0.029
Share correctly predicted (dep var=0)			0.984	0.999
Observations	4839	2668	4839	2668

Heteroskedastic-consistent standard errors clustered on enterprise are shown in parentheses.

Period dummies for the three different CIS waves and sector dummies are included in all regressions.

Table 8
Performance regressions by sector

Dependent variable	*Log (Share/(1-Share))*				*Average employment growth*	
	Sales share - product new to the mkt		*Sales share - product new to the firm*		*1998-2006*	
	Manufacturing	*KIBS*	*Manufacturing*	*KIBS*	*Manufacturing*	*KIBS*
D (has EPO or UK patent)	0.453 (0.090)***	1.072 (0.239)***	0.032 (0.075)	-0.300 (0.148)**	0.057 (0.067)	0.272 (0.292)
D (has trademarks)	0.047 (0.076)	0.331 (0.169)**	0.058 (0.068)	0.079 (0.135)	0.132 (0.062)**	-0.014 (0.157)
Formal IP important in the 3-digit sector	0.279 (0.159)*	0.086 (0.473)	-0.041 (0.132)	-0.461 (0.442)	-0.242 (0.118)**	1.511 (0.841)*
Informal IP important in the 3-digit sector	0.097 (0.162)	0.798 (0.438)*	0.218 (0.133)	-0.463 (0.413)	0.175 (0.117)	-1.398 (0.786)*
Log (R&D per employee)	-0.107 (0.037)	-0.096 (0.053)*	0.006 (0.029)	0.113 (0.051)**	-0.018 (0.036)	0.027 (0.065)
D (no R&D)	-0.220 (0.122)	-0.346 (0.194)	-0.002 (0.095)	0.322 (0.161)**	-0.045 (0.104)	-0.108 (0.223)
Log age	-0.237 (0.046)***	-0.265 (0.058)***	-0.159 (0.039)***	-0.295 (0.065)***	-0.326 (0.055)***	-0.482 (0.073)***
Log employment	-0.031 (0.038)	-0.058 (0.069)	-0.060 (0.033)*	0.146 (0.069)**	0.126 (0.047)***	0.178 (0.104)*
Log employment squared	0.013 (0.007)*	0.013 (0.011)	-0.004 (0.006)	0.029 (0.013)**	0.053 (0.014)***	0.037 (0.021)*
D (exports)	-0.059 (0.095)	-0.012 (0.197)	0.073 (0.035)**	0.168 (0.060)***	-0.219 (0.063)***	-0.342 (0.151)**
D (member of a group)	0.023 (0.059)	0.105 (0.102)	0.056 (0.058)	0.108 (0.089)	0.085 (0.036)**	0.104 (0.122)
D (foreign-owned)	0.148 (0.055)**	-0.119 (0.087)	0.052 (0.046)	-0.039 (0.086)	0.019 (0.038)	-0.145 (0.103)
R-squared	0.055	0.086	0.168	0.106	0.084	0.055
Standard error	1.50	1.71	1.42	1.65	1.04	1.75
Observations	4,839	2,668	4,839	2,668	3,358	1,629

Heteroskedastic-consistent standard errors clustered on enterprise are shown in parentheses.

Period dummies for the three different CIS waves and sector dummies are included in all regressions.