An analysis of the association between the use of intellectual property by UK SMEs and subsequent performance

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Summary

This report analyses the 2001 cohort of UK SMEs. The specific focus is on the link between IP activity in 2001 and subsequent performance (to 2004). The 2001 cohort contains 130,082 SMEs of which 3,123 were IP active (2.4%). Specifically, 1,872 SMEs had at least one UK trade mark publication; 697 had one or more Community trade mark registrations; 646 SMEs had one or more UK patents; and 443 had one or more EPO patent publications.

The outcome and financial performance of the SMEs is analysed in various ways. Initially, we look at the determinants of survival to 2004. We then look at growth of assets and turnover for the period 2001 to 2004. Finally, the analysis considers average profitability for the period 2002 to 2004.

A summary of key findings is contained in the Conclusion.

This report is one of two completed in October 2007. The companion report looks at the characteristics of IP active SMEs and is entitled "An analysis of the characteristics of small and medium enterprises that use intellectual property". This report also documents the creation of the major new database that makes these reports possible – called the Oxford Firm Level Intellectual Property (OFLIP) database

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Copies of the reports can be accessed at:

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1. Introduction

This report is the second report arising from a research project into the use of intellectual property (IP) by UK small and medium sized enterprises (SMEs) over the period 2001 to 2005. The first report gave an overview of the characteristics and trends of SME IP usage, together with a comparison to large and micro firms. This report provides an analysis of how IP affects subsequent performance. At the outset it is worth stressing that uncovering the ultimate drivers of firm level performance is a difficult task. An important feature of SMEs is that they are highly heterogeneous, both in the resources they have and the strategies they pursue. Indeed one of the strengths of a market economy is that entrepreneurship, diversity and experimentation are activity encouraged. Uncovering the exact blend of these activities that lead to success or failure is an impossible task. Nevertheless, policy is acutely interested in understanding how certain factors at the enterprise, industry or economy level may affect performance. Large scale data analysis – as used in this report – is an important technique in investigating such factors. The data used in this report is especially valuable since it covers the entire population of SMEs in the UK in 2001 and investigates the survival and financial performance of these SMEs in 2004.

The specific focus of analysis is the use of IP by SMEs in 2001. The data include four different types of IP: the number of UK patents published; EPO patent publications; UK trade mark publications; and Community trade mark registrations. Overall, 3,123 SMEs used one of more of these IP types in 2001, which is around 2.4% of all UK SMEs. The central question throughout this report is how the subsequent performance of these SMEs was influenced by the IP they obtained.

1.1. Background

1.1.1. FAME database

The broad characteristics of the Financial Analysis Made Easy (FAME) are as follows. The FAME database tracks all registered companies in the UK (i.e. those registered as limited companies at Companies House). In the December 2006 edition of FAME there are around 2.4 million 'active' firms or companies. The words 'firm', 'company' and 'enterprise' are used as synonyms in this report. All of these firms have basic information, such as name, registered address, directors and registered number. For firms that have filed a set of annual accounts there is also some financial data available. The extent of this financial data varies substantially across firms, as the smallest firms legally need only report very basic balance sheet data (namely shareholders' funds and total assets). The FAME data also lists around 0.9 million 'inactive' limited companies. 'Inactive' refers to firms that have been dissolved, liquidated, entered receivership or declared non-trading.

1.1.2. Defining small and medium sized enterprises (SMEs)

This research project is concerned with small and medium sized enterprises (SMEs). The

European Union defines SMEs using three criteria: employment, turnover and assets. Since total assets are the most common financial variable in the FAME database, we define an initial SME group using this variable. According to the EU, an SME must have total assets greater than Euro 2 million and less than or equal to Euro 43 million (Euros are converted to £'s at the rate of 1.49). We then consider firms that have employment data (only around 3% of FAME firms report employment). Any firm that has employment greater than or equal to 250 is reclassified as a 'large' firm. In addition, any firm whose total asset value is less than Euro 2 million but has employment greater than or equal to 10 is reclassified as an SME.

Next we consider firms that are subsidiaries of other firms. The FAME data contains a variable for the 'ultimate holding company' of any subsidiary (this is based on last available accounts). If an SME is wholly owned by a holding firm that is a 'large' firm it is inappropriate to treat the firm as an SME.[1] Hence, any SME wholly owned by a large holding firm is reclassified as a 'large' firm. Similarly, any micro firm wholly owned by an SME is reclassified as an SME. In situations where a firm is owned by two or more holding firms we do not reclassify it.

Reclassifying an SME according to the size of its holding company is only possible if there is data on holding company size. For UK holding companies, FAME has this information. However, in the case of foreign owned SMEs there is no data on the size of the holding company. FAME provides only limited information on the nature of foreign holding companies (for example, in over 80% of cases there is no information on size of shareholding). This presents a problem since excluding foreign owned SMEs could remove many majority owned UK firms; however, in some cases – such as being owned by Ford or Toshiba – it is important to know. Given this, the analysis below controls for the presence of foreign-owned SMEs where appropriate.

Finally, the decision to track performance to 2004 (not 2005) is due to the fact that the FAME Dec 2006 database does not have accounting data for many firms in 2005 (due to delays in filing financial accounts).

As discussed in Report 1, we believe that FAME provides an accurate picture of all registered firms in the UK, hence the 2001 SME cohort that provides the starting point for this report can be viewed as the full population of UK registered SMEs.

The number of SMEs listed in the FAME database is shown in Table 1 for each of the years 2001 to 2005. In this report we focus attention on the 130,082 SMEs in 2001. The choice of 2001 is made to allow three years of subsequent performance to be analysed. As can be seen from Table 1, the number of SMEs increases through time. This is, in

[1] For example, if we were analysing whether SME access to finance was an issue for policy, the inclusion of subsidiaries of large firms could bias results. Subsidiaries are likely to benefit from the resources of the larger group in terms of finance, skills and knowledge.

part, due to firm growth moving firms from micro to SME categories (and this is not offset by moves from SME to large categories). There are also newly incorporated firms that meet the SME criteria.[2] Overall, we have no evidence suggesting the 2001 cohort should be atypical from any other year. [3] As discussed below, the outcome for each of these SMEs will vary. Some will still be SMEs in 2004 – although they could have grown or shrunk in size. Some will have grown sufficiently to enter the large firms' category, while others will now be micro firms. Some 2001 SMEs will also have exited the industry. It is these outcomes that this report analyses.

Table 1 Coverage of SMEs in FAME and IP active SMEs (2001-2005)

Year	All SMEs	IP active SMEs	%	Foreign owned IP active SMEs
2001	130, 082	3,123	2.41%	574
2002	138,243	3,365	2.43%	577
2003	148,215	3,330	2.25%	547
2004	158,221	3,325	2.10%	506
2005	159,399	3,547	2.23%	514
2001-2005	213,855	10,269	4.80%	1,604

Note: SMEs are defined in the main text. IP active SMEs are those that had one or more publications of IP in a given year.

Table 1 also shows the number of foreign owned SMEs in the sample of IP active firms. As mentioned above, we do not have full information of the nature of foreign ownership (e.g. whether wholly or partly owned). There is reasonable coverage of the country of ownership, which shows that the leading country is the US (with around 200 SMEs, or 40%), followed by Japan, France and Germany (with around 6% each).

1.1.3. IP data

The IP data used in the research comes from three different sources: the UK IP Office, Marquesa Ltd and European Patent Office (EPO) ESPACE Bulletin. Data on UK patent

[2] In the period 2001 to 2004 new entrants account for between 3.02 and 3.27% of total SMEs. In 2005, the number of new entrants in FAME is 2,419, or 1.52%. This is likely to reflect the fact that newly incorporated firms can often extend the time before they need to submit a set of accounts at Companies House and our data come from Nov 2006 edition of FAME.

[3] One argument why different year cohorts could experience different outcomes is that the business cycle varies through time. The previous footnote showed that new SME entry was relatively stable in 2001 to 2004. Equally, any business cycle is likely to affect all firms in a similar way (although it is possible that innovative firms may be less affected by business cycles). In any event, the UK economy has been relatively stable across these years (GDP growth was 2.2% in 2001, 2.0% in 2002, 2.5% in 2003 and 3.2% in 2004).

publications were supplied by the UK IP Office.[4] Marquesa Ltd supplied data on UK trade mark publications and Community marks registered.[5] The Community trade mark data did include International Marks designating the EU (OHIM allowed these since 1st October 2004). Data on EPO publications by British entities was downloaded from ESPACE Bulletin DVD 2006/001. Therefore, in this report, an IP active SME has one or more publications in a given year from: UK patent publications, UK trade mark publications, EPO patent publications, or Community trade mark registrations. Appendix 2 provides some background about the different types of IP.

2. SME IP activity in 2001

This section takes a brief look at the cohort of SME firms that were trading in 2001. Report 1 analysed a wide range of factors relating to IP activity, hence this section provides only a short summary.

Figure 1 shows the absolute numbers of publications by the 2001 SME cohort. As can be seen, publications of UK trade marks dominates IP activity with 3,147. There are 1,159 Community trade mark registrations in 2001 by SMEs. In terms of patenting activity, SMEs published 1,048 UK patents and 790 EPO publications. Figure 2 shows the numbers of SMEs involved in IP activity. UK trade marks again dominate with 1,872 SMEs having at least one publication. Thereafter, Community trade marking SMEs (697) just exceeds UK patenting SMEs (646), with EPO SMEs being the lowest number (443).

[4] The authors gratefully acknowledge the support of Jim Houlihan, Graham Jarman and their colleagues at the UKIP.

[5] The data supplied on Community trade marks did not have a publication year. Community trade marks are issued by the Office for Harmonisation of Internal Market (OHIM). The authors gratefully acknowledge the support of Christopher Durrant and colleagues at Marquesa.

Figure 1 **Amount of intellectual property acquired by SMEs (2001)**

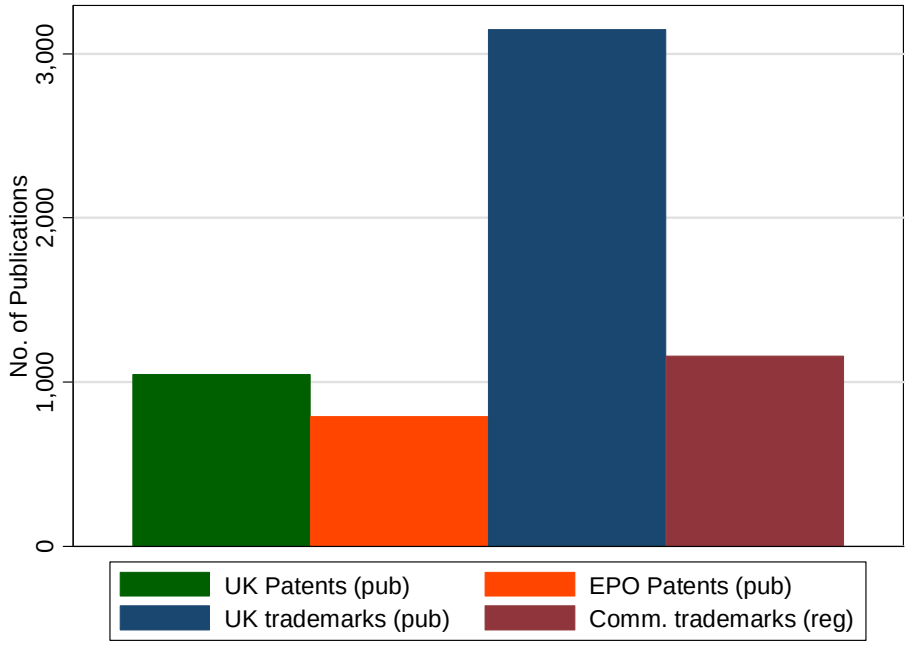
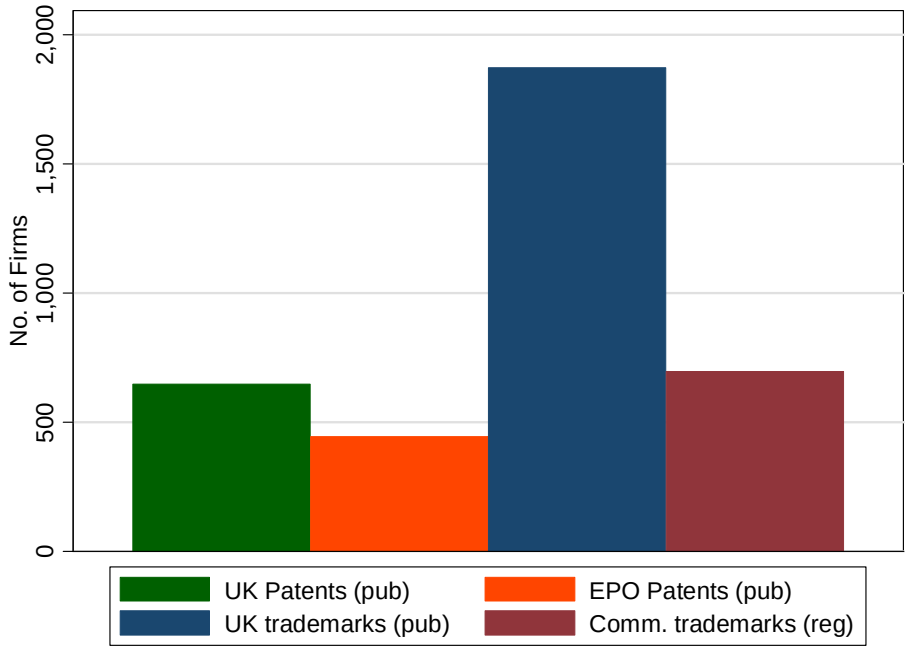


Figure 2 **Numbers of SMEs taking out intellectual property (2001)**



The age structure of all SMEs in 2001 is shown in the first column in Table 2. In subsequent columns the table shows the breakdown for the different types of IP. In general, IP active SMEs tend to be under-represented in their first year of life, as would

certainly be expected for patents (due to the 18 months delay in publication after application). There is also a delay from application to publication of a trademark, which would account for under representation. For trade marks, two and three year old SMEs are over-represented; suggesting that a trade mark(s) is part of early stage strategies for some SMEs. Recall, however, that 97.6% of SMEs are not IP active in 2001. Younger SMEs continue to be over represented for Community trade marks, indicating that this new form of IP protection is relatively under used by older SMEs.

For SMEs that patent, Table 2 shows that a disproportionate number of UK patentees are older SMEs: 68% of UK patentees are over 10 years of age as opposed to only 58% of all SMEs in the 2001 cohort. This is not true for EPO patenting SMEs. For EPO activity it is SMEs between 6 and 10 years of age that are the most active.

Table 2 Age of SME and IP activity (for 2001)

Firm age (years)	All SMEs	UK TM Active SMEs	Com. TM Active SMEs	UK Pat Active SMEs	EPO patent Active SMEs
1	3.05	1.18	1.00	1.08	0.90
2	5.43	6.84	6.89	4.02	4.06
3	5.55	7.26	10.19	2.94	4.06
4	4.99	4.22	6.60	4.64	4.29
5	4.89	4.97	7.75	4.18	6.55
6 – 10	17.86	17.63	20.09	15.48	21.90
10+	58.23	57.91	47.49	67.65	58.24
Number of firms	130,082	1,872	697	646	443

Note: Table shows the percentage of firms in age range shown. The columns indicate the sample of firms. 'All SMEs' are all SMEs in FAME data. 'UK TM' are SMEs that are trade mark active, etc

3. Overview of outcomes

By 2004 one of four things can have happened to the SMEs as defined in 2001: it could remain an SME; it could have grown to become a large firm; it could have shrunk to become a micro firm; or it could have "exited". The micro and large categories are defined as according to standard definitions.[6] An SME that has "exited" is a firm that has ceased to trade (more details are given below).

[6] As is implicit from the discussion of defining SMEs, a micro firm has assets less than Euro 2 million, while a large firm has assets greater than Euro 43 million.

As Table 3 shows, of the 130,082 SMEs in 2001 there were 101,434 still classified as SMEs in 2004 (78%). These SMEs may have experienced growth (or decline) during the period, but they still come within the SME definition. The table also shows 6.39% became large firms, 10.35% became micro firms, and 5.26% exited. The table also shows the outcomes of IP active firms (in 2001); this column indicates that IP active firms were more likely to become larger and less likely to exit – although the difference in exit rate is small, 4.97% versus 5.26% for non-IP active firm. The slightly better outcome for IP active firms could be due to many reasons. It could be that the IP right itself aids performance, or the knowledge behind the IP raises performance. Alternatively, it could be that IP active firms are located in regions or industries where outcomes are more favourable generally. Controlling for such factors is undertaken in the rest of this report.

We also made a preliminary investigation into how many SMEs were taken over or merged during the period. Using data from Zephyr (a Bureau van Dyck database on M&A activity) we managed to find 244 SMEs (from the 2001 cohort) that had been the target of a merger or acquisition; 22 of these were IP active firms (9.02%). As shown in Table 1, around 2.4% of all SMEs are IP active, lower that the 9% of M&A targets. This indicates that IP active SMEs are more likely to be involved in M&A activity. However, we do not develop this analysis due to concerns that the Zephyr data may not fully capture all SME M&A activity.

Table 3 Outcome of 2001 SME cohort in 2004

Outcome groups in 2004	Not IP active in 2001		IP active in 2001		All firms	
	No.	%	No.	%	No.	%
Large	8,115	6.39	240	7.69	8,355	6.42
SME	98,974	77.96	2,460	78.85	101,434	78.0
Micro	13,200	10.40	265	8.49	13,465	10.35
Exited	6,673	5.26	155	4.97	6,828	5.25
Total	126,962	100	3,120	100	130,082	100

Note: A Chi^2 test of the differences between IP active and non-active is significant at the 1% level.

3.1. Exited firms

Exited firms in FAME belong to one of five groups: dissolved, live/non-trading, liquidated, or in receivership. The category 'dissolved' means that the firm has voluntarily informed Companies House that it has ceased to trade. The 'live/non-trading' category is when a firm is no longer actively trading, or carrying on its main business, but may still

hold assets or investments. Formally, there are two types of 'liquidation': voluntary or non-voluntary. The former is when the directors or creditors have agreed to shut down the company, whereas the latter is when a creditor(s) has taken court action to appoint a receiver. In both cases, firms in liquidation are in the process of ceasing to trade, although the FAME database does not distinguish between the two categories. The 'receivership' category is related to involuntary liquidation since this indicates the firm has an appointed receiver who is in process of deciding the fate of the firm.

As can be seen in Table 4, IP active firms are much less likely to exit by being 'dissolved', but have much more chance of entering liquidation or receivership. Although the reasons for this are difficult to know, it is consistent with the idea that IP active firms experience cash flow problems rather than simply exit since they have no growth potential.

Table 4 Reasons for exit of 2001 cohort of SMEs

Reason for exit	Not IP active in 2001		IP active in 2001		All firms	
	No.	%	No.	%	No.	%
Dissolved	3,975	59.57	57	36.77	4,032	59.05
Liquidation	2,018	30.24	68	43.87	2,086	30.55
Live/Non trading	69	1.03	0	0.00	69	1.01
Receivership	611	9.16	30	19.35	641	9.39
Total	6,673	100	155	100	6,828	100

Note: A Chi^2 test of the differences between IP active and non-active is significant at the 1% level.

4. Does IP reduce the chances of exit?

As we have seen above, IP active SMEs appear slightly less likely to exit when we look at the overall statistics. Further, focusing on SMEs that do exit it also appears that IP active SMEs are more likely to enter liquidation and receivership. While these differences are thought provoking, it may be that they are driven by regional, industry or other effects unrelated to IP. For example, an important characteristic that influences survival is the age of the firm. Generally we would expect that as the firm becomes older – and as a result survives in the market place – it gains more and more experience. This experience should further increase its chances of survival, although it may be the case that there is a limit to relevant experience (e.g. maybe after 15 years an SME is as 'experienced' as it can be). Since the IP activity of SMEs is correlated to age (see Table 2) it is important that we control for this factor as well.

In this section we control for these and other factors that might obscure the true relationship of IP and survival. This is done by using a multivariate statistical technique called probit analysis. The probit analysis investigates the role of IP in exit while controlling for a range of other factors.[7]

4.1. Controlling for age, market characteristics and other factors

This section controls for a wide range of basic characteristics that may affect exit. This is done primarily to check the relationship of IP activity to exit, but the results on the various variables are also interesting in their own right. We are also able to check the relationship of each of the four types of IP with exit.

A set of variables relating to IP activity is shown in Table 5. The initial variables are dummy variables, which take 0 or 1 values. For example, if an SME had one or more UK patents published in 2001 it gets a value 1, if not, it gets a value of 0. Dummy variables are used in the analysis to estimate the relationship of IP activity on the probability of exit.

In general, we might expect IP to reduce the probability of exit by an SME. A traditional view of owners or managers is that they should consider the costs and benefits of applying for IP and only undertake the process if there is a net positive benefit. Even if some firms are overly optimistic in their decision making, since we are looking at data on large numbers of firms, our analysis should find the average effect of IP. Furthermore, the publication of an IP right is likely to be correlated with good management and strategy, which are also likely to reduce exit probability. However, the argument above is really concerned with the net present benefit (or profits) from obtaining IP, rather than reducing the probability of exit. Hence it may be that an SME chooses a high risk strategy, which includes applying for IP, and this could result in a higher exit rate. The high risk strategy is chosen since its net present value is higher (i.e. despite the higher probability of failure the rewards if successful are very high and outweigh the failure risk).[8] Given these issues, the relationship between the IP dummy variables and probability of exit is not known a priori.

Table 5 also shows a dummy variable for whether the patent was joint with another applicant. It takes a value of 1 if the publication was joint or, in the case of multiple

[7] Our analysis simply considers whether a firm has failed by 2004, making no distinction between firms that failed in 2002, 2003 or 2004. A more sophisticated analysis can consider the year of failure or the actual time elapsed since the 2001.

[8] A further possibility is that SME owners or managers may not be attempting to maximise profits. Instead they may maximise their 'satisfaction' or 'utility' from their role in the SME. For some owners and managers their satisfaction might include applying for IP since it may provide both interest and status.

publications, if any of the publications were joint. This variable aims to capture whether the SME has access to a wide knowledge base and, if so, we might expect it to reduce probability of exit.

Table 5 IP-related variables for exit model

IP variable	Relationship with exit probability	Expected sign of relationship
IP usage dummies		
Dummy UK patentee	Applying for IP protection should assist SMEs in generating profits in the future.	Reduce probability of SME exit
Dummy EPO patentee	IP use may also be correlated with good management practice and strategy.	
Dummy UK trade marker	These should reduce probability of exit.	
Dummy Community trade marker	Alternatively, applying for IP could indicate a high risk strategy and an increased probability of exit.	Increase probability of SME exit
Dummy for joint patentee	This indicates SME is working with other firm(s) and may have access to greater knowledge or resources	Reduce probability of exit
Industry IP intensity		
Large firm UK patent intensity	High values may indicate mature industry with extensive cross licensing.	Increase probability of SME exit
Large firm UK trade mark intensity	High values may indicate high product innovation by large firms.	Increase or decrease probability of SME exit.
SME UK patent intensity	High values may indicate high technological opportunities in industry in early stage of product cycle.	Reduce probability of SME exit
SME UK trade mark intensity	High values may indicate product innovation by SMEs, hence competition between SMEs.	Increase probability of SME exit

Note: The industry variables are defined at the SIC 3-digit level. For SME industry intensity we calculate the intensity of other firms in the industry.

The second panel of variables in Table 5 relate to IP activity by other firms in the 3-digit SIC industry (SIC stands for 'Standard Industrial Classification). We look at the IP activity of large firms in the industry, as well as SME activity in the industry. Furthermore, we look at trade marks and patents separately. We have calculated these variables for both UK and EPO patents, and for UK and Community trade marks, but here we focus on UK IP activity (although provisional analysis indicates that this choice does not greatly affect results). These industry level variables aim to capture specific characteristics related to innovation that may impact on SME survival. Previous studies on firm survival have attempted to proxy the stage of the product cycle and the balance of innovation between large firms and SMEs (see Jensen et al, 2006; Cefis and Marsili, 2005; Audrestch and Mahmood, 1995). The industry based IP intensity variables are

defined as number of publications divided by industry total assets (in millions). The importance of distinguishing between large and SMEs is that this can capture the maturity of the industry and also the nature of technological opportunity facing firms. For example, in industries where large firm patent activity is high, this indicates that the industry is mature and technological opportunities require large scale to exploit. It may also indicate the existence of substantial cross-licensing (this is sometimes thought to act as a barrier to SMEs or new entrants). In contrast, when there is high patent activity by SMEs this may indicate early stage of product cycle and technological opportunities exploitable by SMEs.

The use of trade mark data to construct parallel proxies for industry activity is much less common. Greenhalgh and Rogers (2007) use trade mark data in a similar way, although they do not have SME trade mark data. Trade mark activity is likely to proxy the amount of product innovation occurring in an industry. It may also proxy advertising and marketing investment (variables which are not normally available in empirical studies). Once again, the analysis distinguishes between large firm and SME trade mark activity. As in the case of patents, it is likely that these variables proxy differences in product innovation across industries.

The variables shown in Table 6 are used as further controls for the probability of exit. Since these variables are not the focus of this report we will not discuss these in detail, although brief explanations are contained in the table.

Table 6 Other control variables for SME exit model

Control variables	Relationship with survival
Addition firm level variables	
Age	This is defined as ln(age). Older firms have accumulated more experience, and experience should increase survival. The log transformation indicates that a year of experience is worth less as the firm gets older
Age squared	This allows further flexibility in how experience varies with age. A negative coefficient on this variable is often found in the literature indicating marginal benefit of age falls with age.
Dummy for foreign ownership	These SMEs may be able to call upon financial assistance from owners overseas. Alternatively, these SMEs may be shut down if underperforming (as foreign owners may easily be able to transfer production abroad).
Dummy for located at university address	These firms are likely to be start-up SMEs hence might expect positive relationship with exit. If university is providing support (e.g. subsidized rent) then could be negative relationship.
Subsidiary (of SME)	Indicates SME is part of group and may have access to external resources and this may lower exit probability.
Location	
Region dummies	Regions may experience different economic conditions. Also support infrastructure for SMEs may vary (financial, consultancy, skilled labour, etc). (10 regions; see Report 1).
Industry level variables	
Sector dummies	Different sectors may experience different exit rates (11 sectors, including one for 'missing SIC code'; see Report 1)
Industry concentration	Four firm concentration ratio included as control for market characteristic. Expressed as ratio. SIC3 digit level (2001).
Average first year firm assets to industry average.	Expressed as ratio of average size of 1st year firm to average for industry (2001). Smaller this ratio the more disadvantaged newer and smaller firms are.
Industry growth turnover	Average growth rate of industry at SIC3 digit level (2000-2001). Expressed as ratio. Higher growth should indicate more potential for SMEs.
Industry price cost margin	Defined as operating profit less costs divided by sales. Average for firms in industry at SIC3 digit level (2001). Operating profit = profit – depreciation – provisions
Capital to labour ratio	High values indicate capital intensive industry and this may disadvantage SMEs (2001).

Note: Baldwin and Gellatly (2003) contain a more detailed explanation of many of the variables.

4.2. Results of probit analysis

4.2.1. Firm level IP activity

The results of the probit analysis on the probability of exit are shown in Table 7.[9] The IP dummy variables are shown at the top of the table. The row adjacent to the name contains the marginal impact on the probability of exit (calculated at the means of the explanatory variables); below this is the t-statistic. As an example, the first column shows a sample of all SMEs in 2001 and the first number is -0.014 (which is significant at the 1% level). This indicates that SMEs that have one or more UK trade mark publications in 2001 have a 0.014 lower probability of exit (1.4%). In the first column the other firm-level IP dummies show no significant relationships with the probability of exit, although the relationships are all negative.

The table also contains three other columns of results. Each of these restricts the sample to different age cohorts of SMEs. As can be seen, the negative and significant relationship of UK trade marks to exit probability does not hold for the youngest SMEs. In fact, for the youngest SMEs having a Community trade mark registration appears to increase exit probability by 0.027 (this relationship is significant at the 10% level). The regressions with older SMEs – those aged 5 or above – suggest that trade marks reduce exit probability and that patents also have negative (although not significant) relationships with exit probability.

Rather surprisingly, the joint patent dummy has positive marginal effects in the full sample and the oldest SMEs (aged 11 and above), although these results are only significant at the 10% level. This indicates that joint patenting does not bring the expected benefits from networking or widening the knowledge base, although as discussed above, more investigation is needed to assess whether joint patentees are using a high risk strategy.

4.2.2. Industry level IP activity

The industry level IP variables results are shown next in Table 7. The main result is that higher UK trade mark intensity by large firms is associated with reduced probability of SME exit. The reasons for such a relationship are not uncovered by this type of analysis, but we suggest that higher trade marking indicates more product innovation and more opportunities for SMEs. The magnitude of the relationship requires us to specify a change in the value of large firm trade mark intensity. A one standard deviation increase change (0.002 trade marks per million assets) is associated with a 0.004 fall in probability of exit (0.4%).

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[9] The sample size in the probits is reduced to 114,276 due to missing data. In particular, many SMEs do not have an industry classification in FAME (15,398). Out of the 3,120 IP active firms in 2001 only 97 do not have an industry classification (around 3% compared to 11% for full sample).

There is some evidence that higher trade marking by other SMEs in the industry leads to higher probability of exit – presumably due to a direct competitive effect – although this is driven by SMEs in the 5 to 10 age range. A one standard deviation increase in this variable (0.0065 trade marks per million assets) is associated with a 0.003 rise in probability of exit (0.3%). Industry level patenting activity, whether by large firms or other SMEs, does not appear to have any strong relationship with SME exit probability. This result indicates that patenting activity within industries does not have an effect on the average SME in that industry. It may well be that the inter-firm effects relating to patents act predominantly on only those firms that patent (or do R&D), something which our analysis does not investigate. Further analysis could look for spillover or other effects by including measures of technological proximity (e.g. by using patent class data as in Jaffe, 1986).

Table 7 Probit results for exit model

	All SMEs	Age < 5	Age 5 to 10	Age >=11
Dummy for UK trade marks (2001)	-0.014	0.001	-0.021	-0.016
	(3.53)**	(0.15)	(2.25)*	(3.49)**
Dummy for Comm. trade marks (2001)	-0.003	0.027	-0.013	-0.017
	(0.44)	(1.84)	(0.92)	(1.97)*
Dummy for UK patents (2001)	-0.011	-0.011	-0.007	-0.010
	(1.33)	(0.45)	(0.34)	(1.11)
Dummy for EPO patents (2001)	-0.009	0.014	-0.016	-0.010
	(1.02)	(0.55)	(0.84)	(1.04)
UK pat per mill. asset SIC3 Large firms	0.213	0.087	1.610	-0.301
	(0.50)	(0.10)	(1.84)	(0.50)
UKTM per mill. asset SIC3 Large firms	-2.000	-2.592	-3.999	-1.163
	(5.68)**	(2.45)*	(4.02)**	(3.23)**
UK pat per mill. asset SIC3 SME firms	-0.288	-0.047	-0.367	-0.306
	(1.51)	(0.08)	(0.76)	(1.48)
UKTM per mill. asset SIC3 SME firms	0.209	0.314	0.481	0.093
	(2.04)*	(1.07)	(1.87)	(0.84)
Joint patent dummy	0.025	0.018	-0.010	0.037
	(1.65)	(0.56)	(0.31)	(1.79)
Age	-0.002	0.028	0.002	-0.001
	(21.86)**	(3.78)**	(0.25)	(7.53)**
Age squared	0.000	-0.006	0.000	0.000
	(15.57)**	(4.06)**	(0.35)	(5.73)**
ln(number of directors)	0.020	0.010	0.023	0.022
	(20.89)**	(3.72)**	(10.04)**	(19.53)**
Dummy for foreign owned	-0.028	-0.032	-0.039	-0.022
	(19.58)**	(10.12)**	(11.74)**	(12.74)**
Subsidiary of SME	-0.043	-0.069	-0.056	-0.029
	(35.49)**	(22.92)**	(19.88)**	(20.18)**
Dummy for located at university	-0.029		-0.041	-0.016
	(2.21)*		(1.74)	(0.86)
Four firm concentration ratio (SIC3)	-0.014	-0.019	-0.016	-0.009
	(3.52)**	(2.08)*	(1.77)	(2.00)*
Industry turnover growth all firms (SIC3)	-0.003	-0.005	-0.003	-0.003
	(2.32)*	(1.60)	(0.83)	(2.04)*
Capital per worker (SIC3)	0.002	0.001	0.002	0.003
	(3.45)**	(0.42)	(1.52)	(3.47)**
Ratio av. 1st year firm assets / aver. (SIC3)	0.069	0.725	-0.091	0.036
	(0.20)	(0.57)	(0.10)	(0.10)
Price cost margin (SIC3)	0.003	0.005	0.005	-0.003
	(3.18)**	(3.07)**	(2.83)**	(1.88)
Observations	114276	21663	26642	65946
1 - lnL / lnL_0 (Psuedo R^2)	0.07	0.09	0.07	0.06

Note: Dependent variable is 'exit' (=1 if firm exited by 2004, else =0). Sector and regional dummies are also included as explanatory variables, and are statistically significant. * significant at 5%; ** significant at 1%

4.2.3. Robustness checks and modifications

The results in Table 7 have been checked in various ways. First, financial variables for

liquidity and profitability in 2001 have been added as additional explanatory variables. This reduces the sample size, but does not greatly affect the results of the IP variables. Second, outliers for the continuous variables have been removed and the regressions re-run to ensure that the IP results were not distorted in any way.[10] Third, probit regressions were run for each of the major sectors. The results for manufacturing and wholesale were in keeping with the results in Table 7 and it is clear that these drive the IP-related results. Results on other sectors tended to find insignificant coefficients on the IP variables.

Finally, a preliminary investigation into the role of initial financial conditions was also conducted. A potential concern about SMEs is that they do not have the financial resources to capitalize on opportunities, including those related to IP. One method of assessing this is to use information on liquidity and profitability in 2001 and see if this affects the IP-exit relationship.[11] The SMEs were divided into quartiles according to these variables (i.e. the bottom 25% of SMEs with lowest liquidity, the 25 percentile to 50th percentile, the 50th to 75th, and 75th and above). The probit regressions were then re-run on each of these quartiles separately. If, for example, low liquidity meant that an SME failed to get any benefit from IP we should observe positive marginal effects in the lowest quartile (i.e. an increased probability of exit) and negative marginal effects (i.e. a reduced probability of exit) as the liquidity ratio increased.

The results for liquidity indicated some support for the idea of financial constraints. The marginal effect of UK trade mark dummy was zero in the lowest quartile regression and became negative and significant in the next two quartiles. However, the highest liquidity SMEs also showed no significant relationship between UK trade marking and exit probability.

For profitability there was no clear pattern across the different quartiles. The highest impact of UK trade marks was for the 25th to 50th percentile group of firms (a reduction in exit probability of 0.036 (3.6%)), which might indicate that a trade mark is of most value to SMEs with weak, but not the poorest, profitability.

Overall, the investigation of liquidity and profitability indicated some weak evidence that the benefits of IP may be related to financial conditions of the SME. Specifically, SMEs with financial performance in the middle range of the distribution may gain greatest benefits from IP assets, but the analysis here is preliminary and further research is required.

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[10] An outlier was defined as any value above the 99th percentile of any of the continuous variables.

[11] The liquidity ratio is defined as 'current assets/current liabilities' and is available for around 82% of SMEs. Profitability is defined as 'profit before tax/total assets' and is available for around 57% of SMEs.

5. IP activity (2001) and growth (2001 to 2004)

This section looks at how IP activity in 2001 is related to growth in assets and growth in turnover in the period 2001 to 2004. As has been discussed, total assets is the financial variable with the best coverage in FAME. This is because Companies House requires most firms to report total assets. For this reason we start by looking at growth in assets as a performance measure. The growth of assets is available for 82% of the SMEs in 2001. In contrast, the growth in turnover is available for only 28% of SMEs in 2001.

The mean average annual growth rate of assets over the 2001 to 2004 period is extremely high at 0.55 (or 55%). This is due to the presence of a small number of extremely high growth SMEs. For example, the highest growth SME had £2,000 assets in 2001 and £11.5 million in 2004, yielding a very high growth rate. The median value of asset growth is 0.009 (or 0.9%) per year and this is a much better indicator of typical growth rates. The median growth rate for turnover is 0.037 (3.7%). The difference between these figures indicates that asset growth tends not to track turnover growth. The correlation coefficient between asset and turnover growth is 0.44, which is positive as expected but indicating a less than proportionate relationship.[12] A possible reason is that many SMEs do not need to increase assets in keeping with turnover due to leasing, efficient stock control and, of course, many being service-based industries. The latter issue has some support since the correlation between the two growth rates is higher (0.52) for the manufacturing sector (which is more likely to use traditional assets).

In summary, it is important to look at both asset growth and turnover growth. Asset growth gives us maximum coverage of SMEs, although it may be that it does not fully reflect the growth performance of the SME. Although the growth of turnover is only available for 28% of SMEs in 2001 – a situation that may create a bias towards more successful SMEs – it is likely that this captures SME experience more accurately.

5.1. An initial look at growth performance

An initial way of understanding the growth outcomes is to group firms into poor, weak, solid and high growth categories. This is done on the basis of the quartiles of the full distribution of firms. For example, for growth of assets, the 25th percentile is -5.3% hence all SMEs with growth below this as categorized as "poor". The 50th percentile (the median) is at 0.9% as stated above, hence any SME with growth above -5.3% and below 0.9% is called a "weak" growth SME. SMEs above the median but below the 75th percentile are "solid", with "high" growth firms obtaining the highest growth rates.

[12] The correlation coefficient is calculated excluding SMEs with growth rates above 200% per annum and below -50% per annum to prevent extreme outliers causing bias.

The results in Table 8 show the percentages of SMEs in each growth group according to IP activity. If there was no relationship between IP activity and growth rates one would expect all of the cells to contain close to 25%.[13] Alternatively, if IP activity in 2001 raised growth one would expect to see higher percentages in the 'solid' and 'high' categories. As can be seen from the table, IP active SMEs are over-represented in the 'high' category, and under-represented in the 'weak'. The remaining columns in the table break IP activity into its four components.

For UK trade marking the percentages are higher in both 'solid' and 'high' and lower in 'poor' and 'weak', suggestive of the fact that a UK trade mark in 2001 raises growth in assets. A UK trade mark is likely to be a proxy for the launch of a new product, or a change of marketing for an existing product, hence we cannot claim it is solely the trade mark that raises growth. For Community trade marking we see a polarization of growth performance with more 'high' and 'poor' growth firms. For both types of patenting the main result is that there are more 'poor' growth firms.

Table 8 Growth of assets (2001 to 2004) and IP activity (2001)

Growth quartile	Non-IP active	IP active	UK TM Active	Com TM active	UK patent active	EPO active
Poor growth (1st qtr)	24.9	27.9	24.4	33.4	31.3	35.3
Weak growth (2nd qtr)	25.2	16.7	15.9	15.1	20.6	16.6
Solid growth (3rd qtr)	25.0	24.9	26.2	21.6	24.6	21.7
High growth (4th qtr)	24.9	30.6	33.6	29.9	23.6	26.5

Note: Table shows the percentages of SMEs in each of the four growth groups: poor, weak, solid and high. If there were no association between the column header and the growth groups, we would expect 25.0 in all growth groups. Deviations from this suggest growth and IP are not independent. A Chi^2 test confirms that each of the IP types have a significantly different distribution to non-IP active firms.

To check the results on growth in assets, Table 9 shows a similar set of statistics for growth in turnover in the period 2001 to 2004. Overall, we see a similar, but not so pronounced, set of results. Trade marking tends to raise performance, whereas patenting does not. In the case of UK patenting we cannot reject the hypothesis that there is no relationship between UK patent(s) in 2001 and subsequent growth; for EPO patentees we again see a shift to poorer growth.

[13] More precisely, we would expect the deviation from 25% to be random. The Chi^2 test in the table is a method of assessing whether the deviations are "random". A Chi^2 probability value of 0.00 indicates that the differences are very unlikely to be random.

Table 9 Growth of turnover (2001 to 2004) and IP activity (2001)

Growth quartile	Non-IP active	IP active	UK TM active	Com TM Active	UK patent active	EPO active
Poor growth (1st qtr)	25.1	23.8	20.8	25.9	24.2	32.9
Weak growth (2nd qtr)	25.1	22.8	21.7	23.3	24.2	24.9
Solid growth (3rd qtr)	25.1	24.1	26.1	18.1	26.8	18.6
High growth (4th qtr)	24.8	29.3	31.4	32.7	24.8	23.9

Note: As per Table 8.

Overall, these results suggest the following. Trade marking is more likely to raise growth rates in assets and turnover over the next three years; whereas patenting has little, and perhaps a negative, impact on growth rates. However, it is important to check these results in a more complete model of growth of SME, which is done in the next section.

5.2. A model of growth rates

Some background to the academic literature related to modeling firm-level growth is given in the Appendix. In this section we will start with general statement that a firm's growth rate will depend on a range of firm, industry and economy level factors. Specifically, we will use the same set of variables as used above for the exit analysis (see Table 5 and Table 6). As previously, our main interest is in the IP related variables and we do not discuss the results on other variables.

Table 10 shows the results from an ordinary least squares (OLS) regression with growth of assets as the dependent variable. The very highest growth rate SMEs are excluded from the sample since the very high values tend to greatly distort the coefficient estimates (we comment further on this below).[14] In terms of the IP activity, the results show that only a UK trade mark(s) has a significant association with subsequent growth. Community trade marking, UK patenting or EPO patenting all have no significant association with growth in the next three years.

[14] A high value is defined as growth rate of 248% per annum or above, which is the 99th percentile.

Table 10 Growth in assets regression results

DV = Growth in assets 2001 to 2004	All SMEs	Age < 5	Age 5to10	Age>10
Dummy for UK trade marks (2001)	0.051	0.079	0.072	0.034
	(6.98)**	(3.04)**	(3.97)**	(5.01)**
Dummy for Comm. trade marks (2001)	0.007	0.026	0.003	0.005
	(0.54)	(0.62)	(0.12)	(0.35)
Dummy for UK patents (2001)	-0.010	-0.050	-0.012	-0.003
	(0.84)	(0.75)	(0.38)	(0.26)
Dummy for EPO patents (2001)	-0.003	0.026	-0.036	0.011
	(0.20)	(0.44)	(1.18)	(0.64)
UK pat per mill. asset SIC3 Large firms	-0.562	-0.216	-0.359	-1.040
	(0.78)	(0.12)	(0.23)	(1.25)
UKTM per mill. asset SIC3 Large firms	0.974	0.766	0.129	1.368
	(2.48)*	(0.41)	(0.13)	(3.42)**
UK pat per mill. asset SIC3 SME firms	0.269	-0.011	1.107	0.151
	(0.92)	(0.01)	(1.34)	(0.48)
UKTM per mill. asset SIC3 SME firms	-0.370	-0.079	-0.655	-0.253
	(2.63)**	(0.12)	(1.78)	(1.78)
Joint patent dummy	0.049	0.038	0.052	0.052
	(1.83)	(0.50)	(0.81)	(1.56)
ln(assets) (2001)	-0.014	-0.029	-0.014	-0.003
	(16.66)**	(11.62)**	(7.78)**	(3.13)**
Age	-0.003	-0.044	-0.001	-0.001
	(21.52)**	(2.08)*	(0.07)	(6.09)**
Age squared	0.000	0.004	0.000	0.000
	(16.45)**	(1.12)	(0.18)	(3.76)**
ln(number of directors)	0.001	0.012	-0.002	0.002
	(0.71)	(1.81)	(0.48)	(1.02)
Dummy for foreign owned	-0.012	0.014	-0.019	-0.022
	(3.84)**	(1.36)	(2.93)**	(5.90)**
Subsidiary of SME	-0.018	-0.013	-0.036	-0.021
	(8.64)**	(1.86)	(7.64)**	(9.89)**
Dummy for located at university	-0.040	-0.069	-0.043	-0.031
	(1.76)	(0.85)	(1.23)	(1.06)
Four firm concentration ratio (SIC3)	0.013	0.016	-0.007	0.023
	(2.13)*	(0.85)	(0.51)	(3.62)**
Industry turnover growth all firms (SIC3)	0.001	0.001	0.000	0.001
	(2.05)*	(0.88)	(0.62)	(1.67)
Capital per worker (SIC3)	-0.002	0.002	-0.002	-0.003
	(1.82)	(0.71)	(0.97)	(2.71)**
Ratio av. 1st year firm assets / aver. (SIC3)	-0.819	-1.911	-0.754	-0.857
	(1.96)*	(1.42)	(0.50)	(2.07)*
Price cost margin (SIC3)	-0.001	-0.008	-0.001	-0.003
	(0.39)	(1.40)	(0.24)	(1.63)
Observations	96275	15522	22484	59537
R-squared	0.02	0.02	0.01	0.01

Note: Table shows OLS estimates with White's robust standard errors. Dependent variable is growth in total assets (2001-2004) expressed as ratio (e.g. 0.05 means a 5% per annum growth rate). Firms with growth rates above the 99th percentile (248%) are excluded.

Excluding SMEs with growth in assets above the 99th percentile might be regarded as arbitrary. The results with the full sample of firms have been investigated. First, there are

14 UK trade marking SMEs, 8 CTM SMEs, and 4 SMEs for each of the UK and EPO patentee categories, that are excluded by the constraint. For CTMs there is one SME, with a growth rate of 3,348% per year that greatly distorts the results (inclusion of this firm means the coefficient on CTM dummy is 0.46). For UK TM there is one SME with a growth rate of 5,376% that increases the coefficient on TM dummy to 0.42. For UK patents, there is one firm with growth of 400% that, if included in the sample, increases the coefficient on the patent dummy to 0.40. For the EPO patent dummy the coefficient is not significant even in the full sample regressions. In summary, the SME cohort does contain a relatively small number of very high growth rate firms that do show a positive association between IP activity and subsequent growth. However, focusing on these results gives a non-typical view of IP use, hence we regard the results in Table 10 as more representative. This said, if SMEs use IP as part of a high risk strategy – pursuing ground breaking innovations – it is valid to consider the high growth SME results along with the typical outcome.

The growth in turnover over the 2001 to 2004 period is analysed in Table 11. As before, the table shows the regression results for the sample of firms that exclude growth rates above the 99th percentile (649%). Note that the sample size is much less than that for growth in assets regressions since turnover is available for fewer SMEs.

The results confirm the association of UK trade marking with subsequent growth. The magnitude implied is that a UK trade marker has a 12% higher growth rate. For the youngest SMEs the effect is even higher – at 40% - although this large effect is due to the presence of a small number of very high growth rate SMEs. If we restrict the sample even further to SMEs with growth below 100% per annum, which means excluding 464 SMEs, the coefficient falls to 0.05. Table 11 also shows some support for the impact of Community trade marking. There is a positive and significant coefficient for the full sample of SMEs, although the significance of this result is not confirmed by different age category results. Once again there is no support for the role of patenting in 2001 having a role in increasing growth, at least during the 2001 to 2004 period.

Table 11 Growth in turnover regression results

DV = Growth in turnover 2001 to 2004	All SMEs	Age < 5	Age 5to10	Age>10
Dummy for UK trade marks (2001)	0.123	0.396	0.149	0.020
	(5.23)**	(3.71)**	(3.16)**	(1.81)
Dummy for Comm. trade marks (2001)	0.119	0.250	0.098	0.027
	(2.72)**	(1.53)	(1.47)	(0.86)
Dummy for UK patents (2001)	0.002	0.184	-0.059	0.000
	(0.06)	(0.42)	(1.03)	0.00
Dummy for EPO patents (2001)	0.006	-0.155	0.065	0.033
	(0.11)	(0.74)	(0.64)	(0.57)
UK pat per mill. asset SIC3 Large firms	-0.032	-2.729	-2.702	-0.234
	(0.02)	(0.51)	(1.02)	(0.22)
UKTM per mill. asset SIC3 Large firms	-1.139	1.239	2.870	-2.216
	(1.01)	(0.19)	(0.99)	(2.94)**
UK pat per mill. asset SIC3 SME firms	-0.401	-7.889	1.820	0.438
	(0.62)	(2.00)*	(1.51)	(0.92)
UKTM per mill. asset SIC3 SME firms	0.698	5.754	0.002	-0.095
	(1.51)	(2.23)*	0.00	(0.32)
Joint patent dummy	0.109	0.248	0.047	0.006
	(1.51)	(0.57)	(0.61)	(0.20)
ln(turnover) (2001)	-0.057	-0.140	-0.061	-0.026
	(19.03)**	(13.83)**	(10.11)**	(9.00)**
Age	-0.008	-0.123	-0.041	-0.001
	(19.90)**	(1.40)	(1.11)	(3.13)**
Age squared	0.000	0.001	0.002	0.000
	(16.48)**	(0.04)	(0.89)	(1.77)
ln(number of directors)	0.029	0.172	0.031	0.022
	(5.60)**	(6.16)**	(2.66)**	(4.73)**
Dummy for foreign owned	0.013	0.078	0.001	-0.002
	(1.53)	(2.43)*	(0.06)	(0.30)
Subsidiary of SME	-0.006	-0.053	-0.026	0.000
	(0.90)	(1.89)	(1.92)	(0.06)
Dummy for located at university	-0.109	-0.070	-0.119	-0.064
	(2.99)**	(0.27)	(2.81)**	(2.33)*
Four firm concentration ratio (SIC3)	0.083	0.292	0.080	0.034
	(4.75)**	(3.94)**	(2.44)*	(2.14)*
Industry turnover growth all firms (SIC3)	-0.002	-0.004	-0.001	0.000
	(3.93)**	(2.09)*	(1.56)	(0.82)
Capital per worker (SIC3)	0.010	0.021	0.014	-0.001
	(2.85)**	(1.86)	(2.33)*	(0.19)
Ratio av. 1st year firm assets / aver. (SIC3)	1.999	28.688	3.038	-1.638
	(0.88)	(1.53)	(0.82)	(2.25)*
Price cost margin (SIC3)	0.005	0.001	0.000	0.000
	(0.88)	(0.03)	(0.03)	(0.03)
Observations	35905	5572	8503	21830
R-squared	0.05	0.12	0.04	0.02

Note: Table shows OLS estimates with White's robust standard errors. Dependent variable is growth in turnover (2001-2004) expressed as ratio (e.g. 0.05 means a 5% per annum growth rate). Firms with growth rates above the 99th percentile (689%) are excluded.

6. IP activity (2001) and profitability (2002 to 2004)

This section analyses the possible links between IP activity by SMEs in 2001 and a measure of profitability in the period 2002 to 2004. Profitability is defined as the ratio of net profit before tax to total assets. Ultimately, the profitability of a firm is of critical importance. Persistent low profitability signals that the products, efficiency and strategy of a firm cannot compete in the market place. However, in the short run a firm may deliberately invest in innovation, skills or capital in order to achieve greater profitability in the future. During these periods of investment, profitability may be low or even negative. Since firms that are actively using IP may be making substantial investments, it is not clear a priori what the association with IP activity and profitability would be. This said, one might expect, on average, only young SMEs to be investing at a rate that causes profitability to be very low or even negative. An obvious example of this is new biotech companies that often fund themselves from capital in the early years. Such companies have little turnover but large costs, resulting in negative profits (and profitability).

The mean average profitability (2002 to 2004) for the sample is 0.007 (0.7%), with the highest value 988 (98,880%) and the lowest -1536 (15,360%). Such extreme values are causes by the fact that assets can be very small and, of course, profits can be large positive or negative numbers. For example, the -1536 is caused by one SME having assets of £4,000 and a loss of £18.4 million. These types of extreme values are common in large firm-level data sets of this kind. The median is 0.039 (3.9%), which is much more in keeping with the idea of a standard return on assets invested. These figures reveal the massive dispersion in the data, which presents a problem for any standard regression techniques (such as OLS which is based on a normal distribution). Given this, the next section initially looks at grouping SMEs into quartiles.

6.1. An initial look at profitability

As in the analysis of growth rates, in order to take a first look at IP and subsequent profitability we divide SMEs into four groups: poor, weak, solid and high profitability. Each of these groups is based on the quartiles of the entire distribution of profitability for 2001 SMEs; hence the data has 25% of SMEs in each profit group. Table 13 shows how profitability is distributed among IP active SMEs. For example, in the 'IP active' column we can see that 33.5% of IP active firms are in the 'poor' profitability group and 17.8% in the 'weak' group. If IP activity had no relationship to profitability we would expect there to be 25% in each profit group. The subsequent columns of the table show the distributions for each of the four IP types. For UK trade marks it is the high profitability group (30.5%) that is most over-represented; although the poor profitability group (28.6%) is also over-represented. This is consistent with the idea that obtaining an UK trade mark reflects a product innovation. A product innovation requires associated investment and is inherently risky. On average it appears that most innovations are successful, hence the 30.5% of SMEs achieving high profitability, although many "fail" (hence the 28.6%). In summary, a UK trade mark 'hollows out' the center of the

distribution and such a feature is consistent with product innovation.

Community trade marking firms show a more extreme 'hollowing out' – or polarization – of the distribution than UK trade marking firms. Of the cohort that has a CTM registration in 2001, 44% are in the poor profitability group with only 23.6% in the high group. This is consistent with the idea that a CTM represents a greater (and longer) investment related to the product innovation and that such investment will take more than three years to pay off (recall that profitability is the average for 2002 to 2004). A less benign interpretation is that SMEs that register a CTM in 2001 pursue strategies that engender financial difficulties, hence the low profits. Section 4.2 indicated that Community trade marking had no strong association with exit probability (although the probit results indicated that in young firms a CTM might increase exit probability whereas for older SMEs it might reduce exit, see Table 7). Table 13, 14 and 15 provide some more evidence on how age of SME affects profit performance.

Table 12 also shows how SMEs active in patenting in 2001 perform. Both UK and EPO patentees exhibit the same hollowing out of the distribution, although it is much more pronounced for EPO patentees. Again these results are consistent with a patent publication representing an innovation that is risky and also requires investment. In the case of EPO patenting it could be that the investment is greater over a longer period, or that risk and poor strategy is leading to poor profitability.

Table 12 Profitability (2002-2004) and IP activity (2001)

Profitability (quartile)	Non-IP active	IP active	UK TM Active	Com TM active	UK patent active	EPO active
Poor (1st qtr)	24.7	33.5	28.7	44.0	30.3	48.2
Weak (2nd qtr)	25.3	17.8	18.4	14.1	18.7	14.8
Solid (3rd qtr)	25.2	21.4	22.6	18.3	23.6	12.2
High (4th qtr)	24.9	27.4	30.4	23.6	27.4	24.8

Note: Table shows the percentages of SMEs of the column heading in each of the four profitability groups: poor, weak, solid and high. If there were no association between the column header and the profitability groups, we would expect 25.0 in all growth groups. Deviations from this suggest growth and IP are not independent. A Chi^2 test confirms that each of the IP types have a significantly different distribution to non-IP active firms.

Table 12 looked at all age groups of SMEs together. Since we are interested in how the nexus of IP, innovation, risk and investment affects profitability, it is interesting to break these results down by SME age groups. Younger SMEs are likely to have less established products and rely more on external funding, indeed they may have been set up to exploit the innovation(s) to which the IP relates. Table 13 shows all SMEs under five years of age. Firstly, it is important to note that these younger SMEs perform worse that all SMEs: 35% of the 2001 cohort end up in the poor profitability group. Hence, the outcome for IP active firms should be compared with the first column labelled 'Non-

IP active'. All of the IP types exhibit the hollowing out discussed above, although now it is more extreme with respect to SMEs ending up in the poor profitability group. For example, of the 2001 cohort of young SMEs that register a CTM 72.8% end up in the poor profitability group.[15]

Table 13 SMEs under five years of age: profitability and IP activity

SMEs < 5 years Profitability	Non-IP active	IP active	UK TM Active	Com TM active	UK patent active	EPO active
Poor (1st qtr)	35.2	58.7	50.0	72.8	54.8	69.2
Weak (2nd qtr)	23.8	12.6	13.0	7.8	23.8	12.8
Solid (3rd qtr)	17.5	12.0	15.9	8.7	11.9	5.1
High (4th qtr)	23.6	16.7	21.2	10.7	9.5	12.8

Note: As per Table 12

The situation for older SMEs is shown in Table 14 and Table 15 15. Table 14 shows the results for SMEs aged between 5 and 10. The hollowing out of the middle of the distribution is present, but it is not as pronounced as SMEs under five. Table 15 shows the results for SMEs aged 10 or more. As might be expected, the hollowing out of the distribution is less pronounced. Older SMEs are likely to have established products, cash flow and profits, hence one would expect these to offset the costs of investing in new innovations. This view is supported by the data. Nevertheless, even in the oldest SMEs we still see the polarisation of profit outcomes (at least as experienced in the 2002 to 2004 period). For example, for the SMEs EPO patentees in 2001, 34.5% end up in the poor profitability group.

[15] Section 2 noted that 697 SMEs had at least one CTM (67% of these had one CTM, 19% had two CTMs). There are 172 SMEs under five years of age that registered a CTM (65% of these had one CTM, 22% had two CTMs).

Table 14 SMEs between 5 and 10 years of age: profitability and IP activity

4 < age SMEs <= 10 Profitability	Non-IP active	IP active	UK TM Active	Com TM active	UK patent active	EPO active
Poor (1st qtr)	27.3	41.7	32.5	51.5	45.4	65.3
Weak (2nd qtr)	22.8	11.4	11.8	9.6	9.3	9.5
Solid (3rd qtr)	21.9	12.9	16.6	9.6	9.3	5.3
High (4th qtr)	28.1	34.1	39.1	29.4	36.1	20.0

Note: As per Table 12

Table 15 SMEs over 10 years of age: Profitability and IP activity

4 < age SMEs < 10 Profitability	Non-IP active	IP active	UK TM Active	Com TM active	UK patent active	EPO active
Poor (1st qtr)	21.1	23.5	21.7	27.6	22.2	34.5
Weak (2nd qtr)	26.4	21.6	22.2	19.3	20.8	18.1
Solid (3rd qtr)	28.5	27.3	26.5	27.2	29.5	17.5
High (4th qtr)	24.1	27.6	29.6	25.9	27.4	29.9

Note: As per Table 12 except that the UK patent active distribution is not found to be statistically different from the non-IP active firms by the Chi^2 test.

6.2. A model of profitability

Modeling the profitability of a firm has a long history in economics, although it is fair to say that there is no consensus on the precise model specification. Starting with Bain's (1956) early work on how barriers to entry affected industry profitability, there has been a range of empirical studies that attempt to explain profitability. Various industry level characteristics – such as aggregate patenting, capital intensity or advertising – may influence the profitability level of all firms in the industry. The factors can be thought of as limiting entry and thereby competition. In addition, firm level characteristics – such as innovativeness, size and management – may differentiate firms within an industry. A major problem with such analysis is the strategic interaction between competitors. Almost all existing studies focus on large firms, since there is often only data on large firms. Models of SME profitability can draw on the large firm literature, but there is a paucity of specific models and actual empirical results. For this reason, and given the nature of this report, we will use the same set of explanatory variables as shown in Table 5 and Table 6. We have conducted some checks on whether entering all these variables

distorts the results on key IP variables, but there appears to be no such distortion.

A first result is that using a simple OLS model (as used for the growth regressions) with all explanatory variables fails to find any consistent pattern of significant results for the IP dummy variables. Further investigation revealed that the results were sensitive to outlier values and, unlike with the growth regressions, even OLS regressions excluding the highest and lowest values did not settle into a 'typical' set of results. In view of this a 'robust regression model' was estimated. The robust regression is an algorithm to eliminate extreme and unrepresentative observations. It is a commonly used technique and aims to provide a more 'typical' assessment of the explanatory variables.[16] The robust regression results are shown in Table 16. The results for the full sample of SMEs indicate that UK trade marking in 2001 is associated with a 0.014 (1.4%) higher profitability in the period 2002 to 2004. UK patenting also has a positive association with subsequent profitability (1.6%). In contrast, an EPO publication appears to reduce profitability (1%). These effects are relatively small, but as can see as one looks at the regressions for different age groups these associations can vary substantially. For example, in SMEs aged 1 to 4, Community trade marking in 2001 is associated with a 7% lower profitability, while an EPO publication in 2001 is associated with a 6% lower profitability.

In summary, the results indicate that UK trade marking and UK patenting by SMEs over four years of age is associated with higher profitability in the next 3 years. In contrast, Community and EPO activity in 2001 is associated with lower profitability in younger SMEs. The under fives have around 6-7% lower profitability, with the 10s and under losing around 2-3%. These results are based on robust regression techniques, since standard OLS regressions are volatile as the sample changes. These results are consistent with the more bivariate analysis presented in the previous section, although the regression analysis does not capture the polarization in the distribution. From an economic perspective, these results are consistent with CTM and EPO activity requiring greater investment and costs, which will ultimately pay off. Nevertheless, the presence of low profits implies financial and other support may be especially critical for such SMEs.

[16] More details of such techniques are contained in Rousseuw and Leroy (1985). The specific algorithm used here is: (1) calculate Cook's D for each observation from OLS, (2) observations with values greater than one are given zero weight, (3) re-run regression, (4) calculate $M=med(|e_i-med(e_i)|)$, where e_i is the residual, (5) any observation with an absolute residual greater than 2M receives a downweight of $2M/|e_i|$ (called Huber weights), (6) repeat procedure until maximum change in weights drops below 0.01 (called 'convergence'), (7) based on final regression in step 6, repeat procedure using 'biweights', which are downweights given by $[1-(7e_i/M)^2]^2$, until convergence. The procedure is described in more detail, with appropriate references, in STATA 9.0 reference manual under 'rreg' (www.stata.com).

Table 16 Profitability (2002-2004) robust regression results

DV = Profits / Assets (2002 to 2004)	All SMEs	Age < 5	Age 5to10	Age>10
Dummy for UK trade marks (2001)	0.014	0.000	0.038	0.009
	(5.55)**	(0.01)	(5.66)**	(3.05)**
Dummy for Comm. trade marks (2001)	-0.001	-0.073	-0.016	0.007
	(0.33)	(6.02)**	(1.69)	(1.24)
Dummy for UK patents (2001)	0.016	-0.019	0.041	0.012
	(2.97)**	(0.69)	(2.75)**	(2.21)*
Dummy for EPO patents (2001)	-0.010	-0.057	-0.035	-0.007
	(1.84)	(2.84)**	(2.79)**	(1.09)
UK pat per mill. asset SIC3 Large firms	0.366	2.218	0.362	0.151
	(1.15)	(2.69)**	(0.43)	(0.39)
UKTM per mill. asset SIC3 Large firms	-0.086	-0.568	0.575	-0.017
	(0.45)	(0.74)	(1.09)	(0.08)
UK pat per mill. asset SIC3 SME firms	-0.012	-0.173	-0.236	0.062
	(0.09)	(0.35)	(0.69)	(0.45)
UKTM per mill. asset SIC3 SME firms	0.646	0.640	0.795	0.596
	(9.79)**	(2.63)**	(4.51)**	(8.31)**
Joint patent dummy	-0.018	0.016	-0.077	-0.011
	(2.12)*	(0.54)	(3.53)**	(1.13)
ln(turnover) (2001)	-0.004	-0.010	-0.007	-0.002
	(12.83)**	(10.43)**	(8.68)**	(3.76)**
Age	0.000	0.002	0.007	0.000
	(7.67)**	(0.24)	(1.14)	(5.73)**
Age squared	0.000	0.000	0.000	0.000
	(9.17)**	(0.22)	(0.63)	(2.26)*
ln(number of directors)	-0.005	-0.007	-0.010	-0.006
	(7.39)**	(2.57)*	(5.98)**	(8.45)**
Dummy for foreign owned	0.001	0.005	0.000	0.000
	(1.15)	(1.45)	(0.01)	(0.19)
Subsidiary of SME	-0.001	-0.002	-0.006	0.002
	(1.34)	(0.60)	(2.72)**	(1.73)
Dummy for located at university	-0.029	-0.024	-0.016	-0.043
	(3.35)**	(0.82)	(1.00)	(3.75)**
Four firm concentration ratio	0.000	-0.032	-0.001	0.009
	(0.18)	(4.33)**	(0.15)	(3.17)**
Industry turnover growth all firms (SIC3)	0.000	0.000	0.001	0.000
	(0.84)	(0.47)	(2.35)*	(1.64)
Capital per worker (SIC3)	-0.001	0.000	0.001	-0.001
	(1.25)	(0.05)	(1.32)	(1.45)
Ratio av. 1st year firm assets / aver. (SIC3)	-0.166	1.842	-1.142	0.075
	(0.64)	(1.54)	(1.74)	(0.27)
Price cost margin	0.000	0.001	0.001	-0.001
	(0.25)	(0.36)	(0.87)	(1.58)
Observations	51400	8118	11873	31409

7. Conclusions

This report has analysed the outcomes of the 2001 cohort of SMEs in the UK. The specific focus was on those SMEs that had some form of IP activity in 2001. The main results are bulleted below.

General

7.1 The report analysed the cohort of 130,082 SMEs in 2001. This database represents the entire population of registered SMEs in the UK.

7.2 In 2001, 1,872 SMEs published one or more UK trade marks, 697 SMEs registered one or more Community trade mark, 646 published one or more UK patent and 443 published one or more EPO patent.

7.3 By 2004, only 78% of the 2001 SME cohort remained as SMEs. This percentage is similar for IP active (78.9%) and non-IP active SMEs (79.9%). More IP active SMEs from the 2001 cohort became large firms (7.7% versus 6.4%).

7.4 IP active SMEs in 2001 were slightly less likely to have exited by 2004 (4.97% versus 5.26%). An IP active SME that did exit was much less likely to have been "dissolved", which is when the directors voluntarily close the business down. IP active SMEs are much more likely to be in liquidation or in receivership – both cases where external creditors or courts are likely to be involved.

7.5 A multivariate probit analysis of the factors associated with exit shows that only UK trade marking significantly reduces the probability of exit. A 2001 SME with a UK trade mark faces around a 2% reduction in exit probability.

7.6 In general, UK patenting, EPO patenting or Community trade marking have no significant association with exit probability. This said, their 'coefficients' in the probit analysis are negative, which indicates they could reduce exit probability – and there is little support that they increase exit probability, apart from the case of Community marks impacting positively on the youngest firms.

7.7 An unexpected result is that joint patenting with another entity does not reduce exit probability and, for older SMEs, it may even increase exit probability. One might speculate that ownership disputes may play some role.

7.8 Higher intensity of trade marking by large firms in the SMEs industry (3 digit SIC level) reduces the probability of exit. We interpret this result as being due to large firm trade mark intensity proxying product innovation. More product innovation by large firms may provide SMEs with opportunities. This said, the magnitude of the association is small. In contrast, higher trade mark intensity among competitor SMEs in the industry tends to increase exit probability. This is consistent with competition between SMEs.

Growth of SMEs

7.9 A preliminary method of assessing growth is to categorise SMEs into poor, weak, solid and high growth performers over the 2001 to 2004 period. This is done with each group corresponding to a quartile of the distribution of growth rates. The analysis considers both growth of assets (available for 82% of SMEs) and for turnover (available for 28% of SMEs).

7.10 Using the growth categories the analysis shows that only UK trade markers in 2001 tend to have growth rates higher than normal. For SMEs obtaining a UK patent, EPO patent or Community trade mark in 2001 their growth performance over 2001 to 2004 is mixed. In short, SMEs with these types of IP tend to have more polarized outcomes than non-IP active SMEs, meaning that more SMEs end up in both the "poor" and "high" categories than expected. This feature is most evident when looking at asset growth and is less pronounced when looking at turnover growth (see Table 8 and Table 9).

7.11 Multivariate analysis confirms the result that UK trade marking is associated with higher rates of subsequent growth. Younger SMEs show the largest association (being a UK trade marker is associated with 7% higher asset growth and much higher turnover growth, see Table 10 and Table 11).

7.12 The multivariate analysis finds no significant association of the other three types of IP with subsequent growth, except for some indications that a Community trade mark raises growth in turnover. This said, the multivariate analysis did not attempt to investigate the "polarizing" feature seen in the preliminary analysis.

7.13 The analysis on UK trade marking reveals that a group of high growth SMEs can drive some of the findings. For example, for SMEs aged under five, a UK trade mark in 2001 is associated with a 41% higher rate of turnover. This is driven by 464 SMEs; without these in the regression the associated growth falls to 5%. There are a very small number of high growth SMEs that can also effect the impact of other types of IP. Such cases may be important in understanding the potential role of the IP system.

Profitability of SMEs

7.14 Profitability is defined as the ratio of net profits before tax to total assets averaged over the 2002 to 2004 period. The median value is 0.039 (3.9%) although the distribution has very large variance.

7.15 Using poor, weak, solid and high profitability groups, a feature of 2001 IP active SMEs is that their profitability tends to be pushed towards either 'poor' or 'high' profitability. IP activity seems to "hollow out" the center of the distribution. This is consistent with IP activity proxying innovation. Innovation can be a risky activity for SMEs, hence some fail and end up in the "poor" group, while others succeed and move to "high" profitability. In addition, innovation requires investment and this would tend to reduce profits in the short run hence increasing the numbers in "poor" or "weak" profitability groups.

7.16 The youngest IP active SMEs (age 4 and less) tend to perform poorly in 2002-2004. For example, 69% of EPO active firms in 2001 end up in the "poor" profitability group (the benchmark for this age cohort of SMEs in 35%). The large over representation could be due to large investments associated with patenting, especially EPO patenting. Trade marking and UK patenting by young SMEs also indicates an association with lower subsequent profitability (see Table 13 and Table 16 column 2). These results indicate how important external financing is likely to be to younger SMEs.

7.17 For SMEs aged between 5 and 10 years the analysis indicates that UK trade marking and patenting in 2001 can raise subsequent profitability. The regression results indicate this rise is around 4%. However, these SMEs also show the "hollowing out" of the distribution mentioned above hence there are substantial numbers of UK IP active SMEs whose profitability falls. In contrast, 5 to 10 year old SMEs that use EPO or CTM in 2001 tend to have lower profitability (see Table 14 and 16 column 3).

7.18 For mature SMEs (aged over 10) having a UK patent or UK trade mark published in 2001 is associated with an increase in profitability (Table 16 column 4). CTM or EPO activity shows no significant association with profitability in the regression model. For mature SMEs the analysis still indicates a "hollowing out" of the distribution (see Table 15) but this is no where near as pronounced as for younger SMEs.

Further research

This report is not intended to provide a detailed assessment of future research, but it may be useful to highlight a few possibilities that have been mentioned above.

Spillovers and clusters in IP activity in the UK. The analysis above used some industry level variables for IP activity in the regression models, but little attention was given to this aspect. The extent to which knowledge spillovers occur between firms – including between micro, SMEs and large firms – is of interest to policy makers. The data allows use to test various hypotheses relating to spillovers and also include a geographic aspect (clustering), including proximity to universities. The data on patent and trade marks also include classes, so it is possible to analyse both industrial and 'technological' clusters and spillovers.

Profitability, finance and the benefits of IP. This report has made various comments relating to the nexus of finance, innovation and performance. It is clear that much more analysis could be conducted on the possible financial constraints, the types of IP activity and links to performance. The fact that European IP activity – EPO patents and CTM trade marks – often appeared to be linked to poor performance is especially interesting. This report only had financial data to 2004, which may be too short a period for some investments. It would currently be possible to increase this to 2005. It may also be possible to identify firms that benefited from venture capital by using ownership data in FAME.

High growth SMEs and IP. This report did not investigate the details of the SMEs that performed exceptionally well in the 2001 to 2004 period. Policy may be particularly interested in such firms and the data here allows their identification. Subsequent analysis could include survey or case-study based work.

Micro firms. In the course of identifying the population of SME firms we also identified a very large set of smaller 'micro' firms (see Rogers et al 2007). It would be possible to undertake some similar analysis for these firms, to see how many of the micro class graduated to become SMEs and what factors helped or hindered their growth.

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Appendix 1 A model of firm growth

Oulton (1999) provides an empirical analysis of the growth of UK firms (1989-93). In this paper he focuses on the debate between so-called Gibrat and Galton type behaviour in growth rates. Gibrat (1931) argued that the growth rate of a firm is *independent* of initial firm size; in contrast, Galton's model emphasised regression towards the mean so he asserts that growth rates decline with initial firm size. The Galton case will produce faster growing SMEs relative to large firms, while the Gibrat case suggests all firms maintain their 'ranking'.

Testing the difference between the two models is normally done with an equation like the following (where t is time period and i represents a firm):

$$\ln y_{i,t} = \alpha + \beta \ln y_{i,t-1} + \varepsilon_{i,t}$$

β=1 growth random around trend (Gibrat)

$\beta < 1$ growth falls with firm size (Galton)

In this paper, in order to allow direct insight into growth rates, the above equation has been re-arranged to:

$$\ln y_{i,t} - \ln y_{i,t-1} = growth_{i,t} = \alpha + (\beta - 1) \ln y_{i,t-1} + \phi x_{i,t-1} + u_{i,t}$$

The above has also added in an additional explanatory variable (x_{it}) by way of example (in the main text we add many additional explanatory variables). The Gibrat-Galton debate is now encapsulated in the (β-1) coefficient estimate. If this is a small negative number (as in the regressions above), this means β is close to 1. However, if the coefficient is significant, β is statistically different from 1 so we must still reject the Gibrat model. In other words, even within the SME cohort, growth rates tends to fall with firm size.

Estimating the model suggested by Gibrat's law does face a technical difficulty, which is not tackled here or in Oulton (1999). Specifically, the problem is that the expectation of y_t conditional on y_{t-1} depends on the firm surviving between the periods. If large firms are more likely to survive, then growth rates must be estimated conditional on firms surviving. This can be done by including an "exit rule" variable from a survival analysis. If larger firms are more likely to survive, the "exit rule" is negatively correlated with y_{t-1}. Omitting it, therefore, introduces a downward bias in β. Since the focus of this report is on IP we do not carry out this correction. As an aside, running regressions of growth rates as we do here results in very low R^2. In contrast, regressing $\ln(y_t)$ on $\ln(y_{t-1})$ raises R^2 massively (to 0.8 or above). Explaining growth rates is very difficult.

Appendix 2 Brief explanation of IP types

A trade mark is any 'sign' that can be used to distinguish a product or service. A sign can be any word(s), graphics, figures, images or similar that can act as a distinguishing feature. Trade marks can also be distinctive shapes, colours or sounds, although rather few such applications have been granted. To obtain a trade mark it must be a distinctive mark for your company and not be deceptive or contrary to law or morality.

For a UK company or individual there are two methods of obtaining trade mark protection in the UK. The cheapest method is to apply for a UK trade mark (UKTM) from the UK Patent Office. This will cost around 300 euros. An alternative route is to apply for a Community Trade Mark (CTM). The CTM was introduced in 1996 and is more expensive at around 2000 euros, but a CTM covers all countries in the EU. In both cases, applications for trade marks are examined and then published, allowing a period of time for others to object, before full registration.[17] For UK trade marks we count publications; for CTMs we count registrations. The initial registration lasts for 10 years, at which time a renewal fee is payable (300 euro for UKTMs and 2500 for CTMs). Each trade mark application has to specify a class in which the trade mark is to be used. Multiple classes per single application are allowed, although there is a surcharge for more than three classes.

A patent protects an invention. The basic requirements are that the invention is:

- New
- Has an "inventive step" (meaning it is not obvious to someone in the industry)
- Be capable of being made or used in industry.

Certain categories of invention are excluded, such as mathematical or scientific discoveries.

Protection in the UK can be sought via either the UK IP Office or the European Patent Office. A UK patent costs around £200 and may take around 2 to 3 years from application to grant. If an application meets a set of initial requirements the patent is "published" 18 months after the date of application. It is these "publications" that we count in this report. The cost of an EPO patent varies according to the route used and the designated countries. A simple case might be Euro 4,000. For both UK and EPO patents use of a patent attorney, which is generally thought to be worthwhile, will increase costs considerably.

[17] Some trade mark applications are not registered due to invalid claims or oppositions. The UK Patent Office currently states that around 90% of trade mark applications are registered within 8 months (http://www.ipo.gov.uk/types/tm/t-applying.htm). For Community trade marks, out of the 57,373 applications in 2000 there were 11,495 oppositions. Assuming half of oppositions resulted in registrations the approximate success rate is 90% also. The delay in getting a Community trade mark appears somewhat longer that a UK patent at around 15 months (based on 2004 data at http://oami.eu.int/en/office/stats.htm).