

Innovation and the Survival of New Firms in the UK*

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April 2010

ABSTRACT

This paper analyzes the survival over the subsequent five-year period of the complete cohort of nearly 162,000 limited companies that incorporated in Britain in 2001. The paper focuses on the relationship between innovation and survival at the firm level. The data available allow us to look at the intellectual property (IP) activity of all British firms, including that of the cohort of new firms in 2001. The results indicate that IP activity, measured as patenting and trade-marking, is associated with a considerably lower probability of exit. We also find substantial differences in survival probabilities across sectors. In some sectors patenting is associated with a lower probability of exit; however, trade-marking is associated with lower probability in almost all sectors.

KEYWORDS: Firm survival, intellectual property, start-ups

JEL Classification: D21, L25, L26, M13

*We acknowledge substantive comments from the editor, Lawrence White, and an anonymous referee. We also benefitted from comments from Marcel Fafchamps, Catherine Roux, participants in seminars at Aston Business School, Kiel Institute, London Business School, participants to the 10th Summer Workshop for Young Economists at ZEW Mannheim, and the 35th Conference of the EARIE. Mark Rogers (corresponding author): Harris Manchester College, Mansfield Road, OX1 3TD Oxford, UK, Tel: +44-01865-271018, Fax: +44-1865-271012, mark.rogers@hmc.ox.ac.uk; Christian Helmers: Wolfson College, Linton Road, OX2 6UD Oxford, UK, Tel: +44-1865-274100, Fax: +44-1865-274125, christian.helmers@wolfson.ox.ac.uk.

1 Introduction

The objective of this paper is to analyze the survival over the subsequent five-year period of the complete cohort of nearly 162,000 limited companies that newly incorporated in the United Kingdom in 2001. For this purpose, we estimate firms' survival functions using a simple non-parametric estimator and probit models. The main contribution of this paper is to provide new results that relate to intellectual property (IP) at the firm-level. Our data allow us to look at the patenting and trade-marking activity of all UK firms, including the 162,000 new firms in 2001.

While empirical studies of patenting and performance are common for larger firms, there are relatively few for small firms and virtually none for start-ups. Patent data, especially for small firms, provide one of the few proxies that are available for innovative activities. The use of trade-mark data is also novel, although there is some evidence that trade-marks proxy innovative activity (Greenhalgh and Rogers, 2006, 2007). Given the rich data we can also investigate whether the impact of IP varies across industries. Further, we investigate whether industry-level IP activity by incumbents influences the survival of new firms.

The paper is structured as follows: the next section provides a short summary of the relevant literature on firm survival, as well as studies that use patent and trade-mark data. The third section discusses the data. Section four provides an overview of survival rates across the different sectors. Section five presents the analysis using both non-parametric and probit estimators. Section six concludes.

2 Related literature

2.1 Survival analysis

Disney et al. (2003) provide an analysis of around 140,000 manufacturing establishments in the UK from 1986 to 1991. They find that only around 35 percent of new entrants survive after five years. Those that do survive are around four times larger than are the new entrants (in terms of employment). Survival rates are higher for firms that are part of a group. This represents, to our knowledge, the only recently published, large sample evidence on UK firms.¹

Mata and Portugal (1994) track a cohort of Portuguese manufacturing firms born in 1983 (with at least five employees). They find that start-up size, industry growth, and

¹There is some small sample evidence: for example, Storey and Wynarczyk (1996) analyze 298 micro UK firms in detail, including proxies for the level of human capital or 'talent'. Interestingly, they find that talent has relatively little explanatory power in comparison with age, sector, size, and other, more traditional, explanatory variables.

multi-location firms reduce the likelihood of failure, while entry (by other firms) into the industry increases the likelihood of failure. Taymaz and Ozler (2007) investigate the survival rates of around 70,000 Turkish manufacturing plants (1983-2001), with a specific focus on foreign ownership. Even though foreign plants survive longer, their analysis suggests that this is due to foreign plants' having larger size, greater capital intensity, and other conducive factors. Fritsch et al. (2006) analyze new firm survival in West Germany (1983-2000), including a wide range of industry and regional variables. They find that regional economic factors are very important.

The above studies are typical of survival studies. However, in these and other firm-level studies a major difficulty is accounting for firm heterogeneity, especially for differences in innovative activities. One method of including innovation to some extent is to use industry-level data. Audretsch (1991) analyzes average small firm survival in 295 US industries and its association with innovation. The industry-level innovation variables were derived from identifying new products and processes in over 100 industry journals. Audretsch finds that survival rates can be higher in more innovative industries. Audretsch and Mahmood (1995) use this industry-level variable in a firm-level Cox proportional hazards model of survival for around 12,000 US manufacturing firms that were founded in 1976. They identify a number of factors that are associated with firm survival. The larger is the new firm's employment, relative to the industry's minimum efficiency scale, the higher is the survival rate. New firm survival is lower when industry innovation rates are high. They also find that higher unemployment rates are associated with lower survival rates. In contrast to Disney et al. (2003), they also find that stand-alone companies have a lower likelihood of failure, as compared to branches or subsidiaries. This finding may appear counterintuitive, as one might expect subsidiaries to receive support from parents. However, subsidiaries may be under pressure to perform, and their parents may be quick to close them down if they do not.

However, these studies, like most others, are unable to account for differences in innovation across firms within sectors. Accounting for innovation at the firm-level is potentially important as *entrepreneurs in the same industry are likely to introduce diverse technologies* (Spulber, 2009a: 25). Perez et al. (2004), who analyze a (large) sample of Spanish manufacturing firms, do have a firm-level dummy variable for whether R&D is undertaken, which is positively associated with survival. The Community Innovation Survey (CIS) is another database that contains variables that are related to innovation at the firm-level. For example, by merging the CIS with a database of firms' survival, Cefis and Marsili (2005, 2006) conduct a survival analysis of Dutch manufacturing firms. In Cefis and Marsili (2005) firm-level dummies are used to distinguish between innovating and non-innovating firms in a sample of 3,275 new Dutch firms over the period 1996-2003. They find that innovators benefit from an innovation premium, giving them

longer life expectancies (11 percent longer survival time for innovating firms). Using Pavitt's (1984) sector classification according to technological intensity, they find that firms in technologically more intensive sectors have greater chances of survival, which is in contrast to the findings of Audretsch and Mahmood (1995).

Other work using the CIS (for an example for Ireland and a literature review, see Love et al., 2009) confirms that (self-reported) innovation has a positive association with performance, although the nature of this association varies with other parameters. While the CIS is a valuable database for such work, there are concerns that the self-reported innovation measures might introduce some bias. Also, the CIS is a stratified random sample of firms, and the response rate may also introduce bias (e.g., Cefis and Marsili, 2006, report a 71 percent response rate, although it is much lower in other countries; see Lucking, 2004). For these reasons there is a rationale for using other types of data to complement results from CIS analyses. One possibility is to use IP data to proxy innovation.

Examples of empirical work using IP data at the firm level include Cockburn and Wagner (2010) and Jensen et al. (2006). Cockburn and Wagner (2010) use a small sample of 356 Internet-related firms that made an IPO on the NASDAQ during the dot-com boom between 1998 and 2001. The authors test whether business method patents had any effect on survival compared to patents in 'traditional' categories. They find that patenting is positively related to firm survival and that firms that applied for more patents were less likely to be taken over. However, they find that business method patents did not confer these benefits. Jensen et al. (2006) use a sample of 260,000 Australian firms that were alive at some stage over 1997-2003. They find that trade-marking is associated with greater survival for 'new' firms (post 1997 entry), but that patenting has no significant association with survival.

2.2 Patents and trade-marks

Schumpeter (1934) suggested a distinction between invention, which involves a new discovery, and innovation, which involves the successful implementation of an invention into a commercial product. IP data can capture both aspects of Schumpeter's typology.

Since Schmookler (1966), many researchers have used patents as an indicator of innovation, even though it really only indicates invention. As such, patents have been found to be positively correlated with large firms' productivity and market value (e.g., Hall, 2000; Griliches, 1990; Bloom and Van Reenen, 2002). Thus, firms with a larger number of patents should be expected to be more innovative and, therefore, have a competitive advantage. Note that almost all of the empirical literature in this area is based on samples of large firms, since obtaining data on small firms is difficult. Patents

may also serve strategic purposes, such as deterring and blocking competitors from entering a certain market (Hall and Ziedonis, 2001; Hall, 2007).

Trade-marks have not been extensively used in previous studies, but there is some evidence that they proxy some aspects of the end of the innovation process (just as patents may proxy the start of the process). Fundamentally, trade-marks provide a means of establishing distinctiveness, which is often crucial for indicating a certain level of quality or other characteristics that consumers can expect from a product. As such, trade-marks help consumers reduce search costs, and hence producers are able to sell larger quantities or charge a higher price (Landes and Posner, 1987). This availability of such a signalling function can be integral to the innovation process, since trade-marks generate some protection against imitation. Hence, Greenhalgh and Rogers (2007) argue that trade-marks proxy product innovation by firms (see also Mendonça et al., 2004). Overall, trade-mark data are likely to proxy some new product innovation and also a range of activities that are associated with product innovation, such as marketing, advertising, and design. Perhaps more important, trade-mark data may capture which firms are better at this bundle of activities.

Hence, using information on patents and trade-marks at the firm-level allows us to proxy the ability of new firms to offer new or more efficient technologies and products as well as differentiated goods and services, which are essential for a new firm's success in the market (Spulber, 2009b).

3 The OFLIP database

3.1 General

The data used for our analysis come from the Oxford Firm Level IP (OFLIP) database. The database draws on the Financial Analysis Made Easy (FAME) data that cover the entire population of registered UK firms (FAME downloads data from Companies House records).² OFLIP contains additional information on the IP activity of firms in the form of patents and trade-marks. OFLIP has been constructed by matching the FAME database and a number of firm-level IP datasets.³

The FAME database is a commercial database provided by Bureau van Dijk.⁴ To construct our data set, the December 2006 edition of FAME has been used. It covers around 2.04 million active firms. For all of these firms, basic information, such as name, registered address, firm type, and industry code are available. Availability of financial

²In this paper we use firms to mean registered firms. Hence firm refers to the legal entity that organizes production, in contrast to census-type data that uses the plant or production unit.

³For details on the matching process and further details on the database, see Rogers et al. (2007).

⁴<http://www.bvdep.com/en/FAME.html>

information varies substantially across firms. The smallest firms are legally required to submit only very basic balance sheet information, such as shareholders' funds and total assets. The largest firms provide a large range of profit-and-loss information as well as detailed balance sheet data. Importantly, the FAME database also lists around 0.9 million so called 'inactive' firms. These inactive firms are those that have exited the market and belong to one of the following categories: dissolved, liquidated, entered receivership, or declared non-trading. The fact that FAME tracks inactive firms allows us to identify all firms entering and exiting the market throughout the five-year period observed. FAME gives exact dates for market entry in the form of a firm's incorporation date. To determine the date of exit we use the date that the last set of accounts were filed.⁵ In an attempt to avoid treating exit due to a merger or acquisition (M&A) as a failure, we complemented the data with information on M&A extracted from Bureau van Dijk's ZEPHYR database.⁶ In principle, this allows us to identify all firms that exited due to M&A during the period analyzed. However, according to ZEPHYR, there were only 97 of the 2001 cohort of firms that exited due to M&A. Given this small number, these firms are simply counted as survivors.⁷

The firm-level data are augmented by regional data on house prices and unemployment at the county and unitary authority level (see Appendix).

3.2 IP data

The IP data used for the construction of the OFLIP database come from three different sources: the UK IP Office, Marquesa Ltd., and the European Patent Office (EPO) ESPACE Bulletin. Data on UK patent publications were supplied by the UK IP Office. Marquesa Ltd supplied data on UK trade-mark publications and Community (OHIM) marks registered.⁸ Data on EPO publications by British entities were downloaded from ESPACE Bulletin DVD 2006/001. For our analysis, we use publications of UK patents, trade-marks, and EPO patents, as well as registrations for Community trade-marks (for further details see Appendix).

⁵This is an important advantage of OFLIP over data sets used in previous work, such as Dunne et al. (1989). In cases where the exit date was missing, the date of last annual return or the date of last transaction at Companies House is used instead.

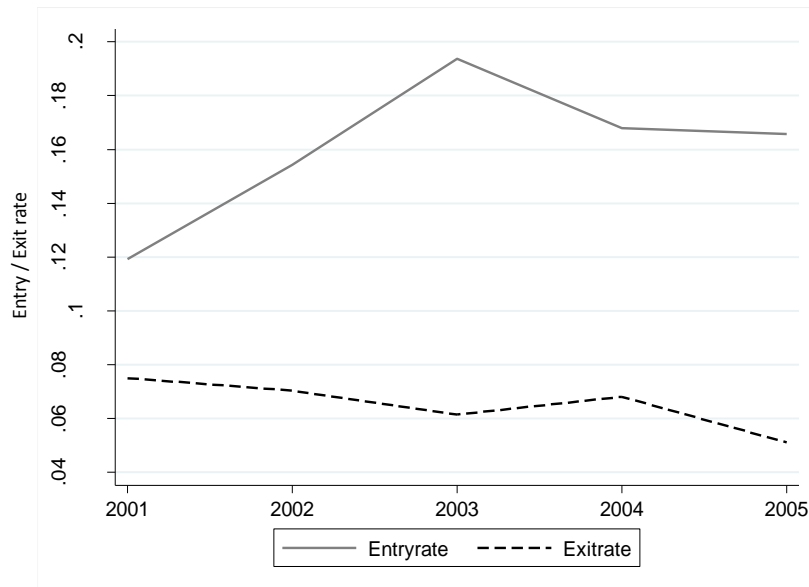
⁶<https://zephyr.bvdep.com>

⁷While Disney et al. (2003) found similarly low numbers for their UK firm-level data set, we acknowledge that some exits due to M&A remain unobserved and we might therefore erroneously regard those exits as failures. Consequently, we will refer to disappearances of firms from the database as 'exits', even though most are likely to be failures.

⁸In the UK, trade-marks can be obtained either through an application to the UK Intellectual Property Office for a UK trade-mark, or through an application to the Office of Harmonization for the Internal Market (OHIM) for a Community trade-mark. Fees differ substantially, as the UK trade-mark costs about 300 Euros, while the Community trade-mark costs around 2000 Euros.

4 Overview of survival

Figure 1: Entry / Exit rates for population of UK firms 2001-2005



Entry and exit rates for the population of registered firms in the UK between 2001 and 2005 are plotted in Figure 1. The exit rate slightly decreased over the period observed, while the entry rate substantially increased between 2001 and 2003. The reason for this was a change in the tax law in 2002. The UK Government introduced a zero percent rate of corporation tax for registered companies with profits up to £10,000. The result of this was to increase rapidly the number of sole traders that formed companies (such as tradespeople and consultants). Over the five-year period shown, entry rates exceeded exit rates on average by 9.5 percentage points. This implies an average annual net increase of around 170,000 firms in the UK. The influence of the tax change is therefore substantial and means that entry rates should be treated with caution. In particular, it is thought that many IT consultants and business service sole traders converted into registered companies in 2002 and 2003.⁹

Our analysis focuses on the cohort of firms that incorporated in 2001; this avoids the problem arising from increased entry rates due to the change in tax regime in 2002.

⁹To counter this unintended effect the government introduced new legislation that taxed all of the company's profit at 19 percent if the profits earned were distributed to shareholders. Hence, the zero percent tax rate applied only up to £10,000, if the profits were retained. These somewhat confusing regulations are now to be abolished, and only a small company tax rate of 19 percent will apply (see HM Revenue and Customs website <http://www.hmrc.gov.uk/>).

Using only firms that incorporated in 2001 also avoids problems of left truncation (i.e., all firms are observed from the onset of the possibility of exit). For our data, there were a total of 161,857 new firms registered in 2001. The survival rates for this cohort are as follows (as of December 31 of each year): in 2002, 160,527 or 99.2 percent were still in business. The high figure simply reflects that a registered company almost always survives to file its first set of accounts. By 2003, 139,138 or 86.0 percent were still in business, with 76.0 percent left by 2004, and 69.7 percent by 2005.

5 Survival Analysis

The previous section noted that about 30 percent of all newly incorporated firms exited over the period 2001-2005. In this section, we analyze firm exit rates using a non-parametric approach and then probit models.

5.1 Non-parametric Analysis

We start by estimating the survival function $S(t)$ using the Kaplan-Meier (1958) estimator. The Kaplan-Meier estimator is a simple frequency non-parametric estimator; i.e., it does not make any assumptions about the distribution of exit times or how covariates shift the hazard function.

The Kaplan-Meier estimator is given by

$$\hat{S}(t) = \prod_{t_i \leq t} \left(1 - \frac{d_i}{n_i}\right) \quad (1)$$

where n_i denotes the number of firms in the risk set at t_i and d_i the number of exits at t_i . The product is over all observed exit times that are less than or equal to t .

Since the Kaplan-Meier estimator estimates the hazard or survival function for each period of risk, we first group firms into year intervals for ease of interpretation.¹⁰ We group the data into IP active and IP inactive firms and estimate the corresponding survival functions for each group. Since IP activity is a proxy for innovation, this can be viewed as a test of survival of innovative firms versus non-innovative firms. We summarize firms' overall IP activity with a single dummy variable that takes the value of one if a firm has obtained any form of IP over the period 2001 to 2005.

¹⁰Since we are grouping continuous data into discrete intervals, we use the so called Lifetable estimator to adjust for grouping. The Lifetable estimator produces an estimate that is centered on the midpoint of the interval in order to account for firms' leaving at different times within the year-interval (Jenkins, 2005).

Figure 2: Survival rates for IP-active and IP-inactive firms

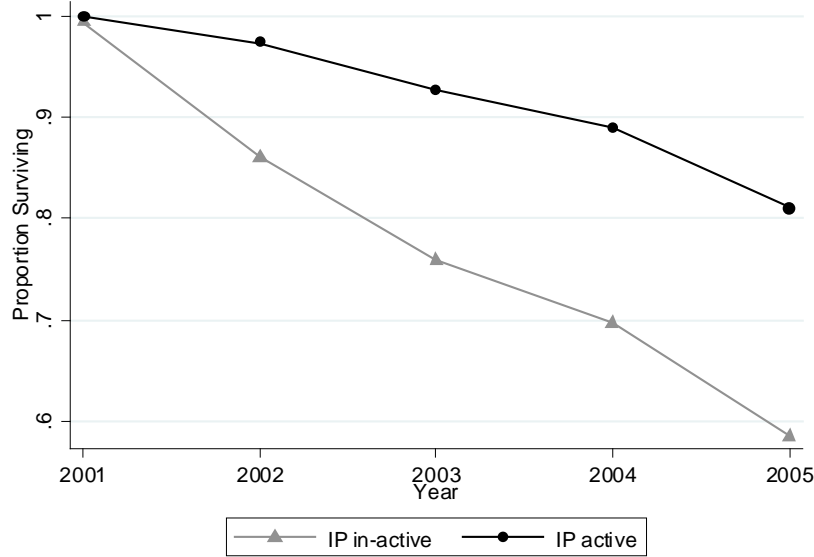


Table 1 shows the results for the Lifetable estimates for both groups. To test more formally whether there is a difference between the two groups, we use the log rank test. The null hypothesis of the log rank test is that there is no difference between groups.¹¹ It clearly rejects the null hypothesis at the 1 percent level for the survival function of IP active and IP inactive firms to be the same.¹² In addition, Figure 2 plots the survival functions for IP-active and IP-inactive groups. The estimated survival function for IP-active firms lies above the survival function for IP-inactive firms throughout the entire time analyzed. Table 1 and Figure 2 provide indicative evidence that IP activity has an important association with survival.

Figure 2 masks considerable heterogeneity across sectors.¹³ Figure 3 plots the survival rates by sector to show the different survival patterns across sectors.¹⁴ Whereas

¹¹One common criticism of the use of the log rank test is that it gives too much weight to later event times as the number of observations in the risk sets become relatively small. This is not the case in our sample as 70 percent of the population survive the five-year interval that is studied which gives 112,887 observations in 2005. We also expect the test to be appropriate as it is best suited as a test for differences between groups when the hazards of the groups are proportional to each other, which can be seen in Figure 2 to hold approximately.

¹²Note that the log rank test yields the same result using continuous rather than grouped data.

¹³The sectors are defined at the SIC 2-digit level as follows: SIC 01-14 Agriculture and Mining; SIC 15-37 Manufacturing (including Recycling); SIC 38-45 Electricity, Gas, Water (EGW), and Construction; SIC 50-55 Wholesale, Retail, Hotel, and Restaurants; SIC 60-64 Transport and Telecommunication; SIC 65-71 Finance and Real Estate; SIC 72 Computer and related activities; SIC 73 R&D; SIC 74 Business Activities; SIC 75-99 Health, Education, Culture, etc.

¹⁴Note that in Figure 3, we exclude all firms for which SIC codes are not available in FAME. This

Table 1: Lifetable estimates for IP active and IP inactive firms

Year	Total no. of firms	No. of exits	S(t)	Std. error
IP inactive				
2001	159,157	958	0.9940	0.0002
2002	157,863	21,198	0.8605	0.0009
2003	136,555	15,954	0.7599	0.0011
2004	120,515	9,872	0.6976	0.0012
2005	110,544	9,556	0.5866	0.0014
IP active				
2001	2,700	1	0.9960	0.0004
2002	2,664	70	0.9733	0.0031
2003	2,583	121	0.9277	0.0050
2004	2,456	100	0.8898	0.0061
2005	2,343	109	0.8107	0.0091
Log-rank test for equality of survivor functions				
$\chi^2(1) = 474.69$ $\Pr > \chi^2 = 0.0000$				

start-ups in the finance and real estate sector (SIC 65-71) have the lowest exit rate, new firms in the computer industry (SIC 72) display a much higher exit rate. The gap in the proportion of firms that survive between these two sectors is over 23 percentage points.

5.2 Probit analysis

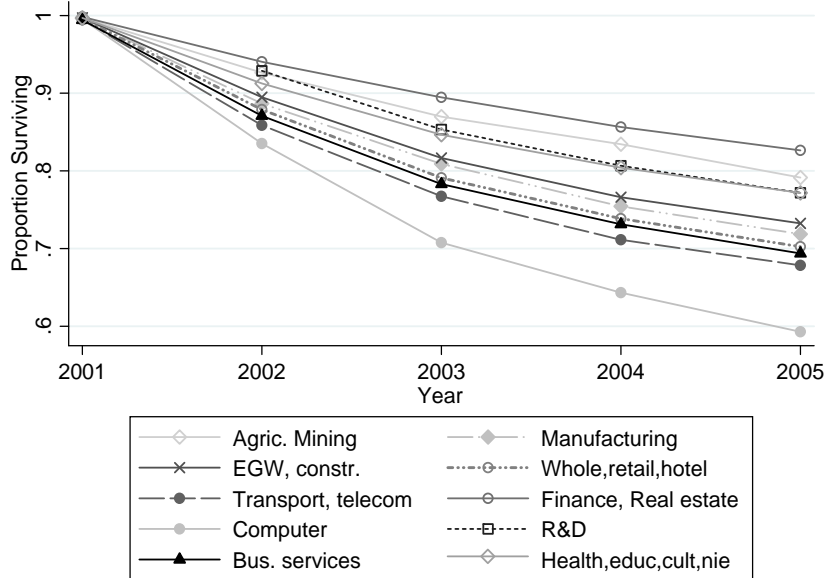
5.2.1 Overview

The dependent variable is a binary variable that equals one if exit occurred any time during the period 2001-2005. The explanatory variables include various industry-, region-, and firm-level factors. Table 2 provides the corresponding summary statistics. Since a principal aim is to analyze industry-level factors, only those firms that specify an industry can be included in the regressions. This reduces the sample to 131,125 firms.¹⁵

There are six industry-level variables that are added to the model. All industry- forces us to drop slightly over 28,000 firms from the sample. Looking at those firms that never report an SIC code, we notice that they are much more likely to exit. A few missing SIC codes may arise from data entry errors, but the numbers are so large that many firms either did not want to report SICs, or exited before they could be obliged to do so.

¹⁵Firms that fail to specify an industry of activity may be simple tax vehicles or highly speculative ventures with no strategy or business plan; hence their omission may limit the sample to ‘economic’ firms.

Figure 3: Survival rates by Sector



level variables have been calculated at the SIC 3-digit level using the *entire* OFLIP database (i.e., *all* firms in the economy). Therefore, they reflect the environment in which the new firms operate. There are two capital-based variables: the capital intensity, computed as the ratio of assets to labor within each industry; and minimum efficiency scale (MES) (the ratio of average first-year firm size to average firm size within the industry, as proposed by Baldwin and Gellatly, 2003). The traditional four-firm concentration ratio (computed using firms' turnover) is also used, as is the growth rate of the industry (2001-2005).¹⁶ We also construct two new variables that may proxy competitive conditions for new firms: the share of firms in an industry that use patents, and the share that use trade-marks. There is debate over whether the patent system helps or hinders small firms (e.g., large firms may generate 'patent thickets'). Similarly, trade-marks can be used strategically to inhibit the scope of new firms to market new products (for a discussion of these issues, see Greenhalgh and Rogers, 2010). However, these new variables may also be correlated with other (unobserved) factors, such as technological opportunity or product innovation. All initial regressions also include a

¹⁶Alternative proxies for competition were explored, such as the Herfindahl index or the price-cost-margin, as is suggested in Aghion et al. (2005); all measures yield very similar results. Note that the four-firm concentration ratio may not be an ideal measure for market structure in service sectors. For this reason, although not shown here, we have also experimented with a measure accounting for spatial concentration; i.e., we summed over the four largest firms in terms of turnover within counties or unitary authorities within SIC 3-digit sectors.

set of sector dummy variables, although we then investigate whether coefficients that are obtained from using the entire sample are the same across sectors.

In the UK there are twelve major regions. These are based on the so-called Regional Development Agencies, which are agencies that coordinate support for new and smaller firms. Economic conditions differ considerably across regions. To account for unobservable region-specific characteristics, we include a set of dummy variables for these regions in our analysis. In addition, we analyze the role of house prices and unemployment at the county and unitary authority level. Like many countries in the world, UK house prices increased dramatically over this period. This is relevant since many new firms borrow using the entrepreneur's house as collateral. Hence, higher house prices may increase entry and prolong survival. However, higher house prices are correlated with higher wages and rents, which may have the converse effect. These issues are investigated using a quadratic function. Unemployment varies substantially across the UK (between zero and 12 percent in our sample). High unemployment implies lower wages and costs (potentially increasing survival), but high unemployment may also mean low demand in the area, which could reduce chances of survival.

The disadvantage of using population data on new firms is that firm-level information is limited. The UK government is not keen to increase compliance costs for small firms; hence reporting requirements are low. Nevertheless, the matching of IP data provides important new variables at the firm-level. Very few firms in our sample use IP (0.35 percent patent and 1.62 percent trade-mark), although it is these firms that may be most innovative. Firm size is a frequent explanatory variable in survival analysis (it shows a positive association with survival, which is to be expected as size reflects experience and success in business). However, in the case of start-up firms, it could be argued that all firms' initial size is zero (at least in terms of sales). More pragmatically, a number of the firms in the sample do not report assets in the first or second year.¹⁷ We use the number of directors as a rough proxy for initial firm size, since all firms must list directors at time of incorporation. The number of directors also reflects the managerial and technical expertise available to the firm.

Using OFLIP we can also construct two other important dummy variables: foreign ownership (2 percent of firms), and whether the firm is a subsidiary (6 percent of firms). In both cases the resources available to the firm may be different from stand-alone firms. Finally, we are also able to construct a proxy for location at a university by searching for keywords in the address of the firm (0.1 percent of firms). Summary statistics for all variables are in Table 2.

¹⁷The UK reporting requirements stipulate that even the smallest firms must report at least shareholders' funds and total assets, but around 5 percent do not report total assets in either 2001 or 2002.

Before interpreting the results, a comment regarding potential endogeneity of the regressors of interest is necessary. Entrepreneurs commonly choose both the timing of entry, and also the market in which they operate, as a function of their own characteristics as well as market opportunities (Spulber, 2009b).¹⁸ In particular, if there are time-varying unobservables influencing firms' decisions to enter a market, our right-hand variables may be correlated with the error term. While we attempt to avoid any such omitted variable bias, our results are best interpreted as correlations, rather than causal relationships.

5.2.2 Results for full sample

Table 3 shows the results from estimating the probit models. Sector and regional dummies are included in all models (and are always significant as a group). All results show the marginal effects. Column 1 uses only binary indicators for patent activity and trade-mark activity.¹⁹ The results show that both patents and trade-marks have significant negative marginal effects, indicating that new firms that patent or trade-mark have a 16 percent lower probability of exiting (before 2005). The second column of results replaces the IP dummies with IP counts and distinguishes between UK and EPO patents, as well as UK and Community trade-marks. Again, all of the coefficients are significant and negative, indicating that a higher intensity of IP activity also increases survival. Note that the coefficient on EPO patent counts is higher than the coefficient on UK patent counts, suggesting that the extra cost of European protection has a payoff, or that better inventions are patented through the EPO. In contrast, the opposite is true for trade-marks: increasing the counts of Community trade-marks has a lower impact than UK trade-marks.

Although not shown in Table 3, the sector and regional dummy variables reveal some interesting differences:²⁰ for example, the marginal effect on manufacturing is 0.083, meaning exit rates are (relatively) higher in manufacturing. In contrast, the results suggest that start-ups in finance have a lower probability of exit (6 percent). Computing start-ups have the lowest survival rates, which is in line with our findings in Figure 3. From a regional perspective, start-ups that are located in London have the least chance of survival.

The third and fourth columns of Table 3 add a range of firm, industry, and regional

¹⁸One may argue that entrepreneurs are constrained in their choice of the market/sector in which they enter depending on their own technical skills and background, which mitigates the endogeneity problem to some degree if we account for such observable characteristics.

¹⁹The variables are equal to one if a firm has had at least one patent or trade-mark, respectively, during the five-year period 2001-2005.

²⁰The omitted sector dummy is 'Agriculture and Mining', and the omitted region is Highlands of Scotland; hence the marginal effects on the other dummies are relative to this.

variables. The marginal effects on the patent and trade-mark variables change only slightly.²¹ If we focus on the industry-level variables, capital intensity shows no significant association with the survival of new firms. The marginal effect for MES is negative but not significant. The standard four-firm concentration ratio has a positive marginal effect, meaning that higher concentration is associated with reduced survival for new firms. The result for industry growth rate, measured by growth in industry-level assets, indicates that firms in higher growth industries experience greater survival.²²

The OFLIP data allow us to include the share of firms in a 3-digit SIC that are trade-mark, or patent, active. The results show that a higher share of trade-markers has a positive association with exit.²³ In contrast, a higher share of patenting firms has a negative association with exit. What might explain these results? Some commentators have highlighted the possible role of patents as generating barriers to entry of new firms (e.g., Hall, 2007), but it may also be that patenting proxies areas of rapid technological change. The results here suggest that the latter dominates. The positive impact of trade-mark share on exit indicates that (cet. par.) survival is more difficult in an industry where distinctiveness (as proxied by a trade-mark) is important

There are two regional variables: house prices and unemployment. A quadratic in the log of house prices is used (other specifications were investigated). The results indicate that higher house prices are initially associated with lower exit rates, but that the strength of this association lessens as house prices rise. In fact, at a threshold level of house price (£243,000, or below the 75th percentile in our sample) this association reverses: higher house prices increase exit. The results are consistent with the idea that houses are used as collateral, but in areas with very high prices this potential benefit is offset by higher rents and wages.

The other non-IP related firm-level explanatory variables in the regressions provide some interesting results. The log of directors, our proxy for initial size and human capital, has a negative marginal effect (the likelihood of exit is reduced as the number of directors increases). Location at a university also reduces exit. This could be due to the spillovers and access to specialist skills and resources, or could be due to generous, on-going subsidies (Audretsch et al., 2005). Start-ups that are foreign-owned, or subsidiaries, also have lower exit rates.

Column five of Table 3 performs a robustness check by including the firm's assets (reported either in 2001 or 2002) among the conditioning variables. This reduces the sample size by 6,514 firms. As can be seen this makes relatively little difference to the

²¹ Although not shown, the relatively high survival rate for start-ups in finance now becomes insignificant.

²² Asset growth is used since data coverage is substantially higher than for turnover or employment.

²³ The marginal effect implies that a one s.d. increase (0.005) is associated with a 0.013 increase in the probability of exit.

coefficients. Although the marginal effect on directors is lower, it is still significant. Column six omits multi-location firms (which are firms that report more than one trading address). These firms have regional variables that are defined only with respect to their head-office address. More problematically, it may be that these firms are larger, or more sophisticated in terms of management or strategy. Hence, the 10,643 multi-location firms are omitted. Overall, the marginal effects of explanatory variables are very similar to before. These robustness checks indicate that the coefficients that are associated with the IP variables change very little (although not shown this is also true for the regressions using IP counts).

5.2.3 Results for sector-level regressions

The large number of observations allows the estimation of the model at the sector-level.²⁴ The results from these are shown in Table 4. Considering the IP variables first, since patenting is not common in some sectors, the patent dummy variable is dropped from agriculture-mining and transport-telecommunication. The marginal effect of patenting is significant, and is associated with lower exit rates, in manufacturing, computing, R&D, and business services. This reflects the importance of patents in these sectors whereas firms in other sectors, such as finance and real estate and wholesale and retail, rely on inventions that are commonly not patentable in the UK. In contrast, firms in these sectors rely more on trade-marks to protect their innovations. As a result, we see negative and statistically significant marginal effects of the trade-mark dummy variable in these sectors. In the wholesale and retail sector, for example, having a trade-mark reduces the probability of dropping out of the market by slightly more than 16 percent. In fact, there are only three sectors where trade-marking does not have a significant association with higher survival. These findings support the use of both patents and trade-marks in the analysis of start-up performance.

Regarding the industry-level variable that measures the share of trade-marking firms, we find the marginal effects to be negative and statistically significant for the computer industry. In contrast, a larger share of trade-marking firms is associated with an increased propensity to exit for the EGW/construction, finance and real estate sector, business services, and health/education sectors. For the share of patenting firms the sector-level results are mixed. There is a negative (insignificant) marginal effect in four sectors, whereas the marginal effect is positive in finance and real estate, computers, and business services.²⁵

²⁴We test the null hypothesis that the coefficients are equal across all ten sectors using a log likelihood ratio test and reject the null hypothesis at the 1 percent level.

²⁵The large variation across sectors in the magnitude of the marginal effects on these variables reflects differences in patent and trade-mark use. In manufacturing the share of trade-marking firms is

For the other industry-level variables there is considerable heterogeneity across sectors. For all of these variables, the signs of the marginal effects vary among sectors, and also the magnitudes of the effects vary considerably. This suggests the presence of important heterogeneity across sectors, which is masked by the results assuming homogeneity of the coefficients across sectors as shown in Table 3. This heterogeneity is consistent with much theoretical industrial organization where competitive conditions are not a simple function of industry characteristics (e.g., Sutton, 1998). Heterogeneity, however, is less important at the firm-level, as the marginal effects on all firm-level variables in the sector regressions are similar to the full sample regressions.

6 Conclusion

This paper analyzes the survival of the complete cohort of all British companies registered in 2001. The database is able to track the outcome of these nearly 162,000 firms through 2005 and also their IP activity during 2001-2005. Intellectual property activity is captured by four measures: UK patent publications, EPO patent publications, UK trade-mark publications, and Community trade-mark registrations. Over the five-year period, 1.85 percent of the 2001 start-up firms use one or more of these forms of IP. The most common form of IP used is a UK trade-mark, followed by Community trade-marks and then UK patents. The dominance of trade-marks reflects two factors: first, obtaining a trade-mark is cheaper and easier than is obtaining patent protection. Second, trade-marks are used by all sectors in the economy; hence they also capture IP activity by service-sector firms. The use of trade-marks in empirical research is novel; hence we should clarify what trade-mark activity indicates. Our expectation is that a trade-mark proxies distinctiveness, which is often essential for the launch of a new, or upgraded, product; hence, we expect a trade-mark often to be associated with innovation. The use of patent data in empirical research is more common, although there are few studies of small, start-up firms.

We investigate firms' propensity to exit the market. However, due to potential endogeneity and unobserved heterogeneity of firms that remains unaccounted for in our analysis, the results cannot be taken as indicating causality. Our main explanatory variables of interest are firm-level IP measures. The results for our preferred specification indicate that new firms with at least one patent experience a 13.9 percent lower probability of exit. Start-ups with at least one trade-mark exhibit a 15.5 percent lower probability of exit. When we disaggregate IP activity into its four components, we find that all types of IP are significantly positively correlated with survival, with the 1.5 percent (the patent share is 1.1 percent), whereas in business services both shares are less than 0.2 percent.

marginal effects being largest for EPO patents and UK trade-marks. These results may reflect the higher quality innovations protected by EPO instead of UK patents. With regard to trade-marks, UK trade-marks may be sufficient to identify unique innovations that belong to a company. Alternatively, a UK trade-mark may best indicate appropriate advertising and marketing effort.

The results also indicate, as expected, that competitive conditions are important. Our measure for market concentration defined at the 3-digit SIC level is statistically significant and positive. The results also show that being located near a university reduces the propensity to exit, as does being foreign owned or being part of a larger group of firms. We also find that firms with more directors have higher survival rates. We interpret the number of directors as a measure of the firm's human, managerial, and technological capital. The analysis also includes variables at the county and unitary authority level to account for spatial differences in economic activity affecting firm survival. Higher unemployment is associated with reduced survival. For house prices, the analysis suggests a quadratic relationship, with higher house prices initially showing a positive association with survival, but this relationship reverses at around £242,000.

Finally, we also analyze the association of our variables of interest with firm survival by sector. The corresponding results uncover important heterogeneity in the relationship between our IP variables and survival across sectors. For the firm-level patenting dummy, the results show a positive significant association with survival in manufacturing, computing, R&D, and business services. In other sectors there is either no patenting activity by start-ups, or the association between patenting and exit is negative but not significant. Trade-marking, however, shows a positive, significant association with survival in all but three of the ten sectors.

Overall, our results show that being IP active is associated with a considerably lower propensity to exit the market within the first five years of a firm's life. Therefore, it is surprising to find such a low share of IP active firms among the entire cohort of new firms in 2001 in the UK. More research is needed to uncover whether this is the result of firms' informed choice or whether other mechanisms are at work.

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A Data Appendix

A.1 IP

In this Section, we briefly describe some issues related to the measurement of the IP variables used in our analysis above.

- **Publication date:** IP is commonly regarded as an output measure of innovation, and we use it as a proxy for the quality of business ideas and firm’s innovativeness. Hence, if the objective is to measure whether it conveys to a firm any competitive edge over its competitors, it seems appropriate to use publication date (registration date in the case of Community trade-marks) as the reference point.²⁶
- **Patent family:** Patent applicants may file the same or very similar applications at several patent offices. For example, firms may apply first for a patent at the UK IP Office and then use the obtained priority date to file for an EPO patent that makes the same, or very similar, claims. Such patents belong to the same patent family, and it is unclear whether they should all be counted as single patents.²⁷ On the one hand, since these patents are based on the same invention, they do not each represent a new innovation by the firm. On the other, as we are interested in whether firms gain any competitive advantage from patenting, such strategic patenting may matter. We therefore count patents pertaining to the same patent family as single patents.
- **Patent heterogeneity:** There is great heterogeneity across patents with respect to their actual value (Schankerman and Pakes, 1986). In particular, it is argued that many patents are of little or no value. The patent literature has developed a number of possible ways to discriminate among patents, including whether a patent was actually granted, the number of citations received, the respective patent family size, renewals, opposition and litigation, and direct values reported by the firms themselves in surveys (van Zeebroeck, 2010). In our situation there are various problems with such methods. Using patent grants for new firms would mean that the firms may already be two-to-four-years old by the time that the patent is granted. In a similar way, the use of citations (or renewals) means waiting for several years after the patent is granted, meaning we could study at the earliest startups in the 1990s. Our data have no information on opposition,

²⁶Note that for trade-marks, the difference between using publication data and registration date is small (around 90 percent of published trade-marks are registered within a few months).

²⁷If exactly the same application is made to both institutions, one of the two has to be withdrawn once one of the institutions grants the patent.

litigation, and patent family size; and, in any event, these may be more important for larger firms. Given this, we adopt a rather crude measure by distinguishing between UK and EPO patents, where EPO patents are considered more valuable. The importance is not only reflected in distinctively higher fees for EPO patents, but also in the international scope of EPO patents. An EPO patent application costs Euro 4000, while a UK patent application costs around Euro 300. In fact, the costs of an application for an EPO patent are likely to be much higher since it needs to be submitted in two languages and the use of a patent attorney is strongly recommended.

A.2 County and unitary authority level

- **House prices:** They are measured as the average price of all property types within a county or unitary authority. The data for England and Wales come from the Land Registry's Residential Property Price Reports.²⁸ The data for Scotland come from the Halifax House Price Index.²⁹ The data for Scotland are available only at a slightly more aggregate level that applies the definitions of the former local government regions of Scotland. Whenever the data are available, we use prices for the final quarter of the preceding year as our measure of house prices.
- **Unemployment rates:** They are measured as the ratio of unemployed over all economically active persons, by county and unitary authority. The data come from the UK Office for National Statistics' Labour Force Survey (LFS), where we calculated annual averages from the quarterly data that are available.³⁰

²⁸<http://www.landreg.gov.uk>

²⁹<http://www.hbosplc.com/economy/housingresearch.asp>

³⁰<http://www.statistics.gov.uk/STATBASE/Source.asp?vlnk=358>

Table 2: Summary Statistics

Variables	Mean	Median	Std. Dev.	Min	Max
Firm-level IP Variables					
Patent Dummy Variable	0.003	0	0.059	0	1
Trade-mark Dummy Variable	0.016	0	0.126	0	1
UK Patent Count	0.005	0	0.176	0	25
EPO Patent Count	0.004	0	0.171	0	40
UK TM Count	0.024	0	0.138	0	23
CTM Count	0.007	0	0.138	0	12
Firm-level Variables					
University	0.001	0	0.028	0	1
Ln no. of Directors	1.662	1.609	0.282	0.693	5.717
Foreign Owned	0.023	0	0.149	0	1
Subsidiary	0.062	0	0.241	0	1
Ln Assets [§]	2.687	2.639	2.249	0	15.976
Sector-level Variables					
Share of TM Firms	0.006	0.006	0.005	0	0.200
Share of Patenting Firms	0.002	0.001	0.005	0	0.100
Capital intensity	1.646	0.749	12.185	0.019	4365.671
MES	0.0001	0	0.001	0	0.038
4-Firm Concentration Ratio	0.282	0.221	0.179	0.055	1
Industry Growth Rate	0.080	0.047	0.286	-0.703	1.584
County / Unitary Authority					
Unemployment rate [†]	0.052	0.052	0.019	0	0.120
Ln Housing prices	12.139	12.149	0.347	10.634	12.704
Ln (Housing prices) ²	147.469	147.596	8.391	113.085	161.388

Notes:

[§] Ln of a firm's total assets in 2001 or 2002 if missing in 2001.

[†] There are two counties with zero unemployment: Isles of Scilly and Western Isles. Both are very small and have one start-up (in 2001) each.

Table 3: Probit Regression Explaining Exit - all sectors (Marginal Effects)

Variables	Coefficient					
	(1)	(2)	(3)	(4)	(5)	(6) [†]
Firm-level IP Variables						
Patent Dummy Variable	-0.157*** (0.016)	..	-0.139*** (0.017)	..	-0.124*** (0.017)	-0.152*** (0.018)
Trade-mark Dummy Variable	-0.166*** (0.007)	..	-0.155*** (0.007)	..	-0.140*** (0.007)	-0.157*** (0.008)
UK Patent Count	..	-0.066*** (0.021)	..	-0.059*** (0.021)	..	..
EPO Patent Count	..	-0.109*** (0.029)	..	-0.099*** (0.029)	..	..
UK TM Count	..	-0.118*** (0.009)	..	-0.110*** (0.009)	..	..
CTM Count	..	-0.060*** (0.013)	..	-0.046*** (0.013)	..	..
Firm-level Variables						
University	..	..	-0.144*** (0.031)	-0.146*** (0.031)	-0.141*** (0.031)	-0.142*** (0.034)
Ln no. of Directors	..	..	-0.059*** (0.004)	-0.059*** (0.005)	-0.034*** (0.005)	-0.059*** (0.005)
Foreign Owned	..	..	-0.138*** (0.006)	-0.137*** (0.006)	-0.114*** (0.007)	-0.143*** (0.006)
Subsidiary	..	..	-0.235*** (0.026)	-0.235*** (0.003)	-0.220*** (0.003)	-0.247*** (0.003)
Ln Assets [§]	-0.051*** (0.005)	..
Sector-level Variables						
Share of Patenting Firms	..	..	-1.614*** (0.468)	-1.676*** (0.468)	-1.299*** (0.476)	-1.786*** (0.503)
Share of TM Firms	..	..	2.558*** (0.290)	2.529*** (0.290)	2.057*** (0.295)	2.855*** (0.310)
Capital intensity	..	..	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0000 (0.0000)
MES	..	..	-0.473 (1.766)	-0.481 (1.767)	-0.238 (1.796)	0.354 (1.904)
4-Firm Concentration Ratio	..	..	0.049*** (0.009)	0.049*** (0.009)	0.046*** (0.009)	0.056*** (0.009)
Industry Growth Rate	..	..	-0.051*** (0.009)	-0.051*** (0.005)	-0.052*** (0.005)	-0.054*** (0.005)
County / Unitary Authority						
Unemployment rate	..	..	1.102*** (0.106)	1.099*** (0.106)	0.996*** (0.107)	1.011*** (0.112)
Ln Housing prices	..	..	-0.614* (0.333)	-0.622* (0.333)	-0.551 (0.336)	-0.671* (0.351)
Ln (Housing prices) ²	..	..	0.025* (0.014)	0.026* (0.014)	0.023 (0.014)	0.027* (0.015)
Industry dummy variables	included	included	included	included	included	included
Region dummy variables	included	included	included	included	included	included
Number of observations:	131,325	131,325	131,325	131,325	124,811	120,682

Notes:

* indicates significance at 10%; ** at 5%; *** at 1%.

[†] Sample omits multi-location firms, i.e., firms that report more than one trading address.

[§] Ln of a firm's total assets in 2001 or 2002 if missing in 2001.

Table 4: Probit Regressions Explaining Exit - by sector (Marginal Effects)

Sector	Agric/ Mining	Manufact.	EGW/ Construction	Whole/Retail/ Hotel	Transport/ Telecom	Finance/ Real Estate	Computer	R&D†	Business Services	Health/Educ/ Cult/nie
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Coefficient									
	Firm-level IP Variables									
Patent Dummy Variable	..	-0.126*** (0.035)	-0.081 (0.108)	-0.077 (0.079)	..	0.146 (0.214)	-0.150*** (0.066)	-0.215*** (0.038)	-0.181*** (0.029)	-0.077 (0.077)
Trade-mark Dummy Variable	-0.101 (0.069)	-0.118*** (0.024)	-0.011 (0.072)	-0.164*** (0.016)	-0.119** (0.057)	-0.129*** (0.009)	-0.235*** (0.024)	..	-0.181*** (0.012)	-0.081*** (0.021)
University	..	-0.187*** (0.072)	..	-0.053 (0.145)	..	..	-0.206* (0.114)	0.028 (0.209)	-0.142** (0.055)	-0.132* (0.067)
Ln no. of Directors	-0.050 (0.047)	-0.027 (0.019)	0.015 (0.017)	-0.048*** (0.013)	-0.028 (0.027)	0.001 (0.010)	-0.111*** (0.017)	-0.052 (0.078)	-0.062*** (0.007)	-0.072*** (0.010)
Foreign Owned	-0.044 (0.062)	-0.151*** (0.023)	-0.055 (0.043)	-0.152*** (0.019)	-0.246*** (0.021)	-0.054*** (0.013)	-0.208*** (0.026)	..	-0.149*** (0.009)	-0.128*** (0.019)
Subsidiary	-0.176*** (0.019)	-0.170*** (0.014)	-0.181*** (0.023)	-0.244*** (0.008)	-0.248*** (0.018)	-0.162*** (0.005)	-0.371*** (0.009)	-0.196*** (0.046)	-0.262*** (0.004)	-0.194*** (0.006)
	Sector-level Variables									
Share of Patenting Firms	3.408 (10.581)	-0.646 (0.578)	-65.629 (43.343)	-6.352 (4.913)	-25.898 (27.762)	93.165*** (20.912)	193.38*** (52.97)	..	187.870*** (33.174)	10.344 (6.429)
Share of TM Firms	3.993 (29.306)	0.329 (0.432)	43.649* (25.732)	1.576* (0.812)	3.562 (2.509)	-0.824 (1.527)	-44.830*** (10.985)	..	50.731*** (7.005)	9.515*** (0.872)
Capital intensity	-0.044 (0.034)	0.004 (0.018)	-0.012 (0.078)	-0.035*** (0.009)	0.176 (0.119)	0.012*** (0.002)	0.791*** (0.167)	..	-0.028*** (0.005)	0.006*** (0.001)
MES	386.163 (613.280)	-2.241 (2.566)	-277.685 (243.080)	-23.338 (30.582)	11.524 (13.186)	47.289*** (15.192)	-37.207 (32.504)	..	-148.285*** (28.268)	-5.156 (3.207)
4-Firm Concentration Ratio	0.227* (0.135)	0.018 (0.038)	0.318 (0.257)	0.013 (0.021)	0.254 (0.159)	0.083*** (0.017)	-0.614*** (0.072)	..	-0.160*** (0.042)	0.151*** (0.029)
Industry Growth Rate	0.056 (0.081)	-0.032* (0.018)	0.191** (0.090)	-0.016 (0.019)	0.157*** (0.060)	0.009 (0.012)	..	..	-0.765*** (0.104)	-0.079*** (0.009)
	County / Unitary Authority									
Unemployment rate	0.556 (1.133)	1.572*** (0.377)	1.294*** (0.360)	1.863*** (0.286)	1.775*** (0.606)	0.379 (0.253)	-1.008** (0.413)	2.038 (1.424)	1.499*** (0.186)	0.565* (0.291)
Ln Housing prices	-8.671*** (3.167)	3.443** (1.456)	-0.453 (1.157)	2.314** (1.009)	-2.432 (1.847)	-0.879 (0.873)	-1.984 (1.268)	10.127 (6.653)	-2.403*** (0.660)	-0.090 (0.945)
Ln (Housing prices) ²	0.365*** (0.132)	-0.145** (0.061)	0.019 (0.048)	-0.095** (0.042)	0.102 (0.077)	0.036 (0.036)	0.082 (0.052)	-0.414 (0.275)	0.099*** (0.027)	0.001 (0.039)
Region dummy variables	included	included	included	included	included	included	included	included	included	included
Number of observations:	1,021	7,381	10,853	17,305	4,377	13,667	13,110	395	46,899	16,247

Notes:
* indicates significance at 10%; ** at 5%; *** at 1%.
† This sector contains only two subsectors, 731 (R&D on natural sciences and engineering) and 732 (R&D on social sciences and humanities), with 354 and 41 firms respectively. For this reason, we drop the SIC 3-digit-level variables from the specification.