Nesta...
WORKING PAPER SERIES

Nesta Working Paper No. 12/13

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Nesta Working Paper 12/13
December 2012

www.nesta.org.uk/wp12-13

Abstract

Despite the importance of high technology firms to the UK's economy, relatively little is known about factors contributing to these firms' long-run growth and survival. We examine these factors using a unique longitudinal dataset combining two waves of detailed surveys of 345 UK high tech firms and performance and survival data. We use a series of OLS, logit and multinomial logit models to explore factors contributing to the performance and survival of these firms. Our results show that long-term survival rates are near two thirds for the firms in our sample, and that performance within the sample is skewed by a limited number of high performing firms. We find that 40% of firms reported difficulty in finding skilled workers, and find that lack of access to skills results in lower long-run growth for these firms. We find that two-thirds of technology firms target overseas markets from birth, and the entry into overseas markets is important for survival and growth. Overall we conclude that the early strategic decisions made by firms have long-run impacts on their survival and growth, and we suggest that policy measures targeted at the shortfalls faced by these firms may have positive long-term consequences.

JEL Classification: J24; O31; O41; O47

Keywords: Technology-based firms; Survival; Growth; High growth firms

We are grateful to Albert Bravo Biosca, Louise Marston, Gordon Murray, Paul Nightingale, an anonymous referee and the participants at NESTA research seminars and the ZEW entrepreneurship conference for valuable comments and discussion. This work contains statistical data from ONS which is Crown Copyright. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates. All remaining errors are our own. Corresponding Author: Josh Siepel, SPRU – Science and Technology Policy, Jubilee Building, University of Sussex, Brighton BN1 9SL, j.siepel@sussex.ac.uk.

1. Introduction

The importance of high technology firms to modern economies has become increasingly apparent over the past twenty years. The rapid growth of companies such as Intel, Google and Genentech from start-ups to global leaders has demonstrated the importance of small technology-based firms as key generators of innovative advantage as well as jobs and wealth. Worldwide, and especially in Europe, a great deal of attention has been paid to the characteristics that enable new high technology firms to succeed (Storey and Tether 1998, Almus and Nerlinger 1999, Colombo and Grilli 2005, Henrekson and Johansson 2010). Consequently a great deal of research has been done on factors contributing to the growth and success of high tech firms.

While there has been considerable interest in the factors contributing to growth and survival of small high tech firms, there has been much less work on these firms' performance over decades rather than years, particularly with regard to the impact of managerial decisions and access to resources. Given increasing interest in barriers to growth for high-growth firms and those with the potential for high growth (see Lee 2011 for recent work), this is a topic of considerable importance. Because these firms are facing situations characterised both by uncertainty around markets and technology (Freel 2005), the importance and magnitude of managerial decisions are amplified. This paper draws upon a unique longitudinal dataset that provides a distinctive perspective on the growth and development of high-tech firms (here defined using the OECD definition, including firms in electronics, software, advanced materials, telecommunications and biotechnology) throughout the firm life course from birth to maturity. This dataset consists of two waves of very detailed questions about management, technology, finance and other key factors. In this paper we join this dataset to detailed performance data, which allows us to examine the long run implications of decisions made by firm managers on the growth and survival of these firms as many approach their third decade in operation.

This dataset has been used previously for a number of other pieces of research. The collection and structure of the data was summarised in Burgel et al (2004). Further analysis has been done on a number of elements in the dataset, including internationalisation (Burgel and Murray 2001, Burgel et al 2004, Coeurderoy et al 2011); sales (Fryges 2005); survival from 1997 to 2003 (Cowling et al 2006); and growth from 1997 to 2003 (Coeurderoy et al 2011). This research, particularly Cowling et al (2006) and Coeurderoy et al (2011), provides an extensive discussion of the impact of firms' strategies between the two frames. Those studies considered the firms in the dataset as they went from 'youth' (0-6 years) to 'adolescence' (6-12 years). This study completes the cycle by examining these firms' long-run performance now that they are 'mature' (12-20 years). Therefore one main contribution of this paper is to extend this dataset to look at the impact of managerial decisions on performance over a fourteen-year period.

This paper examines a number of key elements contributing to long-run growth and survival of UK high technology firms. We do this using a series of variables designed to capture a range of key factors contributing to firm performance: human capital at both entrepreneur and employee level, R&D and technology strategy, market positioning, and finance. We begin by examining the survival of the firms in our sample. High technology firms are generally characterised as high-risk, and as such are widely expected to have higher mortality. We examine the impact of the factors listed above on the long-run survival of the firms in our sample. We then extend our work on survival by incorporating an insight from recent work (see Wennberg et al 2010, Balcaen et al 2011) highlighting the weaknesses of a traditional, binary 'survival/failure' dichotomy. We then provide a deeper examination of survival by linking survival with growth data to give a more nuanced understanding of factors that contribute to firms' ability to thrive in the long run.

The second section of the paper then moves on to consider factors contributing to the long-run growth of the firms in our sample. We draw upon the factors described above, including technology strategy, market positioning, and finance to examine attributes that have contributed to the performance of the firms in this sample. We

examine factors contributing to growth in sales and employment among firms from the dataset in the period between 1997 and 2010, considering the growth between the two waves of the survey as well as the period between the second wave and the present. We analyse both the long-term growth rates as well as annual year-on-year rates of growth in sales and employment. We continue by analysing the highest and lowest-growing quartiles of firms from our dataset in this period, with the aim of understanding, which, if any, factors contribute to particularly high growth. Finally we examine the implications of these managerial decisions on survival. Given the separate but related subjects listed above, we present our results by grouping them into themes, including technology and innovation, market position, human capital, and funding. Following the two empirical sections, the paper concludes by summarising the points made in the paper and raising some policy conclusions based on the findings.

2. Long-run survival and growth for high-technology firms

This research is intended to give a unique perspective on firms' ability to survive and grow throughout their entire life course. Whereas much of the research in the literature is only able to examine firms at one particular point in time, we are able to capture a cohort of firms as they grow from early-stage start-ups into mature firms. The challenges faced by our cohort to survive and grow reflects several fundamental issues: firstly general challenges of surviving and growing as faced by all firms, and secondly more specific challenges facing firms that specialise in technology. This section summarises the literature in this area and generates some hypotheses that will be explored in the subsequent sections. The first section will highlight issues of growth and survival faced by all firms, while the second will identify a number of key areas identified within the literature as being crucial for the growth and survival of technology based firms: R&D and technology strategy, market positioning, finance, and human resources.

2.1 Survival and growth across the life cycle

From the economist's perspective, perhaps the two most elementary struggles faced by any firm are those of survival and growth. The maintenance of a firm's own existence and its ability to increase its turnover and employment are fundamental topics that have been widely (for summaries see Caves 1998 and Cowling 2006 on survival and Coad 2009 on growth). In discussions of growth in the literature, key firm variables such as size, number of founders, initial size[1], and age all play key roles (see, among many Eisenhardt and Schoonhoven 1990, Sutton 1997, Santarelli et al 2004, and Delmar and Shane 2006). As such we use these for controls in our analysis.

In recent years the tools for assessing growth and survival have begun to be re-evaluated. Recent advances have allowed for a stream of literature that uses advanced techniques to examine the fundamental mechanisms or processes of growth (see Coad 2010, Moneta et al 2012; see the latter for a more detailed discussion of recent developments). Meanwhile a similar but more definitional change has emerged in the survival literature. While survival itself tends to be rather binary (a firm is active or it isn't), it is no longer self-evident that survival is 'good' and exit is 'bad'. For instance, the growing body of literature on high-growth firms draws a dichotomy between the small fraction of high-growth firms (6%, as reported in NESTA 2009) who create the majority of new jobs and the majority of firms (termed 'marginal undersized poor performing firms' or 'MUPPEts' by Nightingale and Coad 2012), who do not grow, operate in a limited number of sectors and contribute little to economic growth.

At the same time, the literature on exit has recently emphasised that firms ceasing trading does not equate to failure: Balcaen et al (2010) differentiate between bankruptcy, voluntary liquidation, and mergers and acquisitions as possible means

[1] It is important to remember here that not all new firms are small; statistics on job creation of new firms have in some cases been heavily skewed by 'new' large firms (Nightingale and Coad 2011).

by which firms may exit. Voluntary liquidation and mergers and acquisitions (M&A) in particular represent profitable ways for entrepreneurs to exit firms, even if they are performing well (Wennberg et al 2010, Cefis and Marsili 2011). Further, M&A represents a particularly common means of exit for venture capital-backed firms, especially in Europe, where there is less access to IPO exits and M&A is the most profitable means for VCs to exit (Murray and Mariott 1998, Siepel 2012).

Consequently it is worth considering whether successful firms that cease trading due to voluntary liquidation or M&A are necessarily any less successful or desirable than marginal firms that remain in business but with limited employment, growth or prospects. Yet to this point there has been relatively little in the literature examining the factors that contribute to firms exiting (closing after operating successfully rather than failing), and persisting (continuing to operate but without growing). One contribution of this paper, as presented in Section 4.2, is to present a more nuanced picture of the drivers of firm 'survival' as a more broadly defined term.

2.2 High-technology firms: factors contributing to survival and performance

While all firms face common existential pressures in their battle for survival, some industries face particular challenges due to the nature of competition, and this is particularly true for companies that operate in high-technology sectors. Whereas all firms must utilise resources to develop products and markets, high-tech firms do so under the spectre of an uncertain innovation process and great dependence on human capital, meaning that the risk of starting a business is compounded by the uncertainty surrounding the technology. In this sense high-tech firms face a number of unique challenges. This section highlights several of the issues that have been identified to impact on firm performance and survival.

2.2.1 Human capital

The weaknesses of the binary model of survival described above tend to have knock-on consequences for our understanding of human capital within firms. A binary understanding of survival implicitly supports the notion of the Schumpeterian, 'heroic' entrepreneur. It is easy to assume that 'good' entrepreneurs lead firms that survive (or firms that fail, which then helps the entrepreneurs to learn on subsequent endeavours), while 'bad' entrepreneurs lead firms that fail. Consequently, extensive effort in the literature has been dedicated to the human capital of entrepreneurs and its impact on performance. These are often considered under two categories, following Becker (1975): 'general' human capital, which refers to characteristics such as education or general experience that may be useful in any industry, and 'specific' human capital, which is only useful to one employer or one industry. For an entrepreneur these can include educational background, working overseas or for a multinational company, and experience of working jointly with a partner. The contribution of these factors has been examined extensively in the literature for entrepreneurs, for instance in Bates (1990); Gimeno et al (1997); Davidsson and Honig (2003); and Haber and Reichel (2007). In light of these and the insights on this dataset from previous research (Cowling et al 2006 , Coeurderoy et al 2011) we can hypothesise that founders' human capital (as embodied in experience and education) will have a positive impact on growth and survival.

H1: Founders' human capital (as measured by experience and education) will have a positive impact on growth and survival

While the role of entrepreneurs on firm success is widely discussed, much less attention has been paid to other, non-entrepreneur human capital in firms. The human capital of managers, workers and outsiders has often been overlooked in favour of the entrepreneur or a more general 'individual vs firm' human capital perspective (see Blundell et al 1999) that overlooks different roles within organisations. Consequently this introduces tremendous potential bias by leading us to incorrect assumptions about what makes a 'good' entrepreneur and what makes

a 'bad' entrepreneur. Our data allows us to explore performance outcomes in a much more nuanced way. Specifically we explore the ability of firms to leverage the general and specific human capital among managers and employees in the company to recruit skilled new staff (Leung 2003) and generate growth (as in the findings of Hitt et al 2001). Lee (2011) has identified lack of access to managerial skills as a key barrier to growth for current high growth firms, and we extend this to examine the long-run impact of these shortfalls.

H2: Access to sufficient human capital among staff will have a positive impact on long-run growth and survival.

2.2.2 Innovation and technology strategy

Innovation is important to many firms, but for the small technology-based firms in this study activities involving R&D and innovation management are crucial (Acs and Audretsch 1988, Agarwal 1999). Our research here examines two key elements of the innovation management process. While innovation may take a range of forms (see for instance Tidd 2003 and NESTA 2006) we first consider the R&D activity and R&D intensity of the firm. Firms may produce a technologically advanced product and then cease R&D activities whilst focusing on selling that product, while others may occasionally invest in R&D when needed. Other firms may constantly maintain innovation activities; given the common refrain that innovation is a constant, ongoing process (Freel 2003, Verhees and Meulenberg 2004), the frequency of innovation for otherwise resource-constrained firms remain particularly important. This measure may be considered alongside R&D intensity, defined here as the proportion of a firm's employees who are involved in R&D activity. The intensity of a firm's R&D activities measure of the firm's engagement and investment in human capital for R&D and plays a key role in the firm's ability to develop and exploit technological capabilities (Deeds 2001, Adams et al 2006, Stam and Wennberg 2009). We also consider the nature of the technology that firms may use: they may generate entirely new technologies, adapt existing technologies, or combine other

technologies into novel forms. These represent a range of risk profiles, but the long-range implications of a firm's technology strategy remain relatively unclear (Zahra and Bogner 2001). The importance of innovation has been examined using this dataset in previous research (Cowling et al 2006), which found innovation played a key role in survival as firms age. We therefore are particularly interested in the impact of innovative activities in firms' early life on long-run survival.

H3: Firms' innovative activities will be positively associated with long-run growth and survival.

2.2.3 Product and market positioning

Our work is also interested in the impact of product positioning and strategic decisions on long-run growth and survival. One key strategic decision made by a firm's management, often at an early stage, is the target market in which the firm's products should be positioned (Meyer and Roberts 1988). This decision about where to compete has long been recognised as a key driver of a firm's potential success, but for the case of SMEs the long-run impact of this decision is important but not necessarily well understood (see Fontes and Coombs 1997, Li and Atahene-Gina 2001). An example of this is the decision to expand internationally. Moving into international markets has the potential to give firms access to considerable new areas for growth (Zahra et al 2001, Sapienza et al 2006), and – as seen in previous work on this dataset (see Fryges 2005 and Coeurderoy et al 2011), firms' decisions to enter international markets tends to be a more successful strategy than resource consolidation within a single market. Following from this work, we extend previous analysis to consider the impact of entry of overseas markets on long-term growth, and predict that the positive impact identified previously for internationalisation will continue in the long-run.

H4: Internationalisation will have a positive association with long-run survival and growth.

2.2.4 Financing

Finally we are interested in firms' access to external capital. For high-tech firms, finance is a crucial element required for success (Denis 2004). Given the financially intensive nature of R&D, a firm's ability to access capital is crucial to its long-term ability to exploit any technological advantage. Our research focuses on three common forms of funding for small high tech firms: grants, angel investment and venture capital. Grants are a means of supporting very early stage firms that are widely adopted by policymakers as a means of easing financial constraints on small firms; by avoiding equity investment these may allow firms to develop without the constraints of other equity investors (Wallsten 2000, Siegel et al 2003). Angel investors represent individuals and groups that informally invest in firms, typically at early stages when firms may be IP rich but cash poor (Prowse 1998, Mason and Harrison 2002). Venture capitalists tend to invest larger sums than angels, and bring a more formal, organised approach to investment. Their involvement with early stage firms can be a key contributor to the growth of these firms, but their growth-focused approach is also associated with high rates of failure for firms that cannot keep up (Murray et al 1995; Gompers and Lerner 2002). Importantly, both angel and venture capital investors can serve as valuable sources of external human capital for firms that receive investment (see Greenwood and Steier 1995, Brander et al 2004). As such they may be hypothesised to positively impact the firms in which they invest in terms of growth, but in light of our discussion of the dangers of binary survival as a proxy success, it is important to keep in mind that effects for VC may be limited given the pressure of VCs to generate exit (see Mariott and Murray 1998), which in Europe is more likely to come through mergers and acquisitions (Siepel 2012).

H5: Firms receiving outside capital from grants, angels and VC are more likely to grow, and firms receiving grants and angel investment are more likely to survive.

3. Data

This analysis is based upon a unique, longitudinal dataset of 345 UK firms in six technology-based sectors over the past twenty years. The dataset draws upon performance data as well as the results of detailed managerial surveys that were carried out in the UK originally in 1997 and again in 2003. This, combined with information provided by interviewees about the firms' characteristics upon founding, provides a unique and rich longitudinal perspective on factors contributing to the long-run performance of these firms.

3.1 Sample selection and data collection

While the term 'high tech' is in common usage, the actual categorization of firms as 'high tech' is not a trivial exercise. Our sample uses Butchart's (1987) definitions for high-technology manufacturing sectors in the UK, which is based on the 'ratio of R&D expenditures to sales' and the 'share of employees working in R&D.' Using this definition, Butchart identified nineteen UK 1987 SIC codes, which were translated into the NACE Rev. 1 code. These may loosely be defined to include firms in the electronics, software, advanced materials, telecommunications and biotechnology sectors. One issue with this definition is that the industrial classifications used are now slightly outdated; categories such as 'Telegraph and radio technology' have now been supplanted, making direct one-to-one comparison rather more difficult.

This study is based on two surveys that were carried out in the UK originally in 1997 and again in 2003. The source data set originates from Dunn & Bradstreet in the UK. Using these databases, all firms with at least three employees in 1997 that were operating in one or more high-tech sectors (using the definition above) and having been founded as legally independent companies between 1987 and 1996 were selected; the mean year of founding was 1991. Subsidiaries, de-mergers or firms

that were founded as a management buy-out (MBO) or buy-in (MBI) were excluded from the analysis. This resulted in a population of 3,562 firms from the UK. A random sample of 2,000 firms was drawn from the UK population, stratified by size and sector (particularly manufacturing versus services) to give a representative sample.

These firms were first contacted in winter 1997/1998 via a written questionnaire after an initial series of pilot interviews. Ultimately 362 completed questionnaires were returned. The first survey is described in detail in Bürgel et al. (2004). This research was then followed up with a new survey in which all previously responding firms were to be contacted a second time in 2003. At this date the average respondent firms were approximately 12 years old. To determine the target sample of the second survey, at first all formerly responding firms that turned out to be mismatches (e.g. non-high-tech firms or non- independent or subsidiary companies) or had been identified as dead were excluded, which served to address potential selection bias. As a result, we produced and subsequently contacted a final target sample of 250 UK-based formerly responding firms. This was augmented with a 'new' target sample of 561 firms that was drawn from the original 1997 cohort of identified NTBFs but had not been included in the previous round.

The second survey was conducted in 2003 via computer-aided telephone interviews (CATI). The research team decided on a telephone survey for contacting the 'old' (i.e. 1997) target sample because of the assurance of a relatively high response rate by direct personal contact. This was critical given that a sufficiently high number of repeat observations was necessary to obtain reliable econometric results. In the case of the UK, the 'new' target sample was contacted using a postal survey instrument. The response rate of the 'old' target sample exceeded 50%. After performing several consistency checks, 217 companies were retained in the longitudinal data set. The 2003 cross-sectional data set further contains 193 'new' companies that were added to the study beginning in the second survey. Testing for selection effects using Heckman corrections (results available upon request) provided no meaningful evidence of selection bias.

In order to examine the long-run implications of the managerial decisions outlined in the AGF data, these data were augmented with performance data drawn from the private database FAME and Business Structure Database (BSD) of the Office of National Statistics. The BSD is the most complete record of firm performance in the UK, using VAT figures collected by HM Treasury and employment records from National Insurance to give a uniquely accurate record of the performance of British firms. Using these data sources we were able to accurately track the performance of AGF firms from 1997 – 2010.

For our data we measure growth in several ways. For the analysis of management and market factors contributing to performance, we calculate growth by considering the log difference for several key periods: between 2010 and 1997 (to capture aggregate growth); between 2003 and 1997 (to capture growth following the first survey but not including the second); and between 2010 and 2003 employment and sales (to capture the outcomes following the second survey). For we use the BSD binary coding for whether firms were active from the 2010 data as the basis for our logit analysis.

3.2 Descriptive statistics

While full summaries of the variables are included in the appendix, here we give a general overview of the characteristics of the firms in our sample. The average firm in the sample was founded in 1991, and of those surviving to 2010 the mean employment was approximately 77 with a median of 11, and the mean turnover for £10.2 million, with the median being £959,000. These descriptive statistics indicate the extent to which results are disproportionately skewed toward a small number of high growth firms; when plotted the mean for employment and sales rests comfortably between the 95^{th} and 75^{th} percentiles. This is in line with previous work indicating the disproportionate sales and growth impact of a relatively small number of firms (NESTA 2010). We also see here that recessionary pressures seem to have

generally escaped the firms in the sample – both sales and employment remained constant or growing through the recent recession but only declined toward the end of the period.

Figure 1: Employment over time period by quantile [Source: ONS]

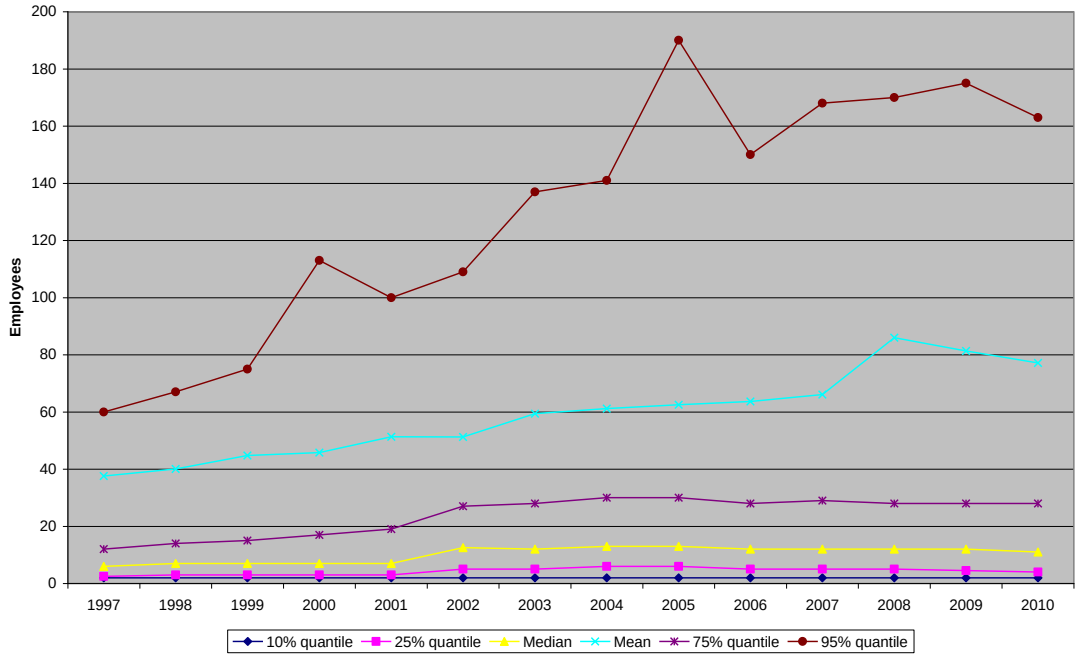
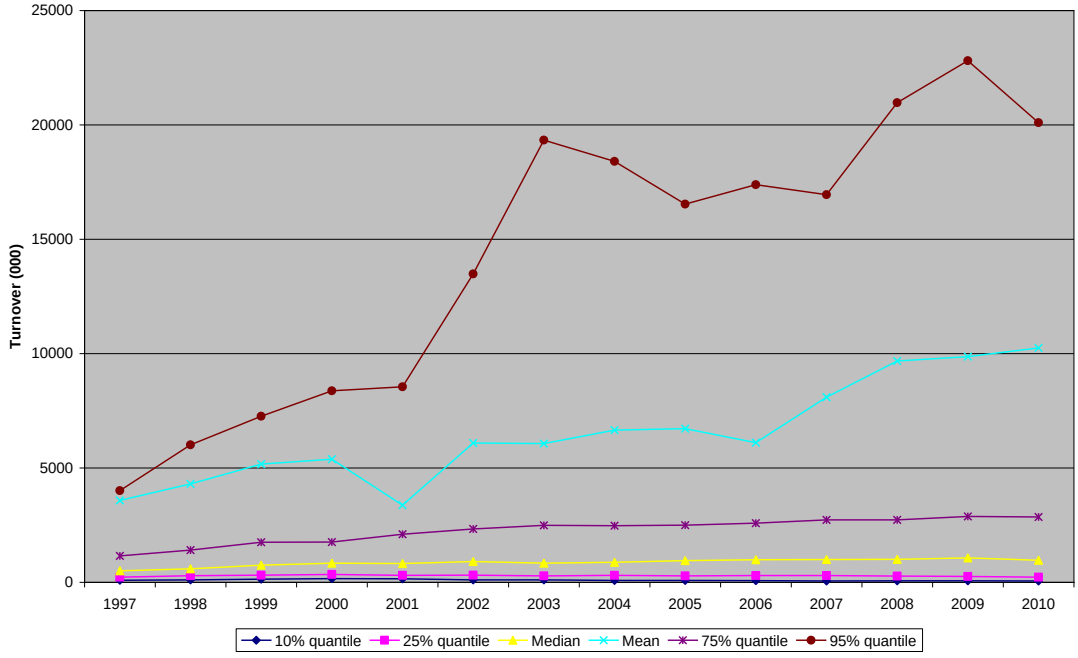
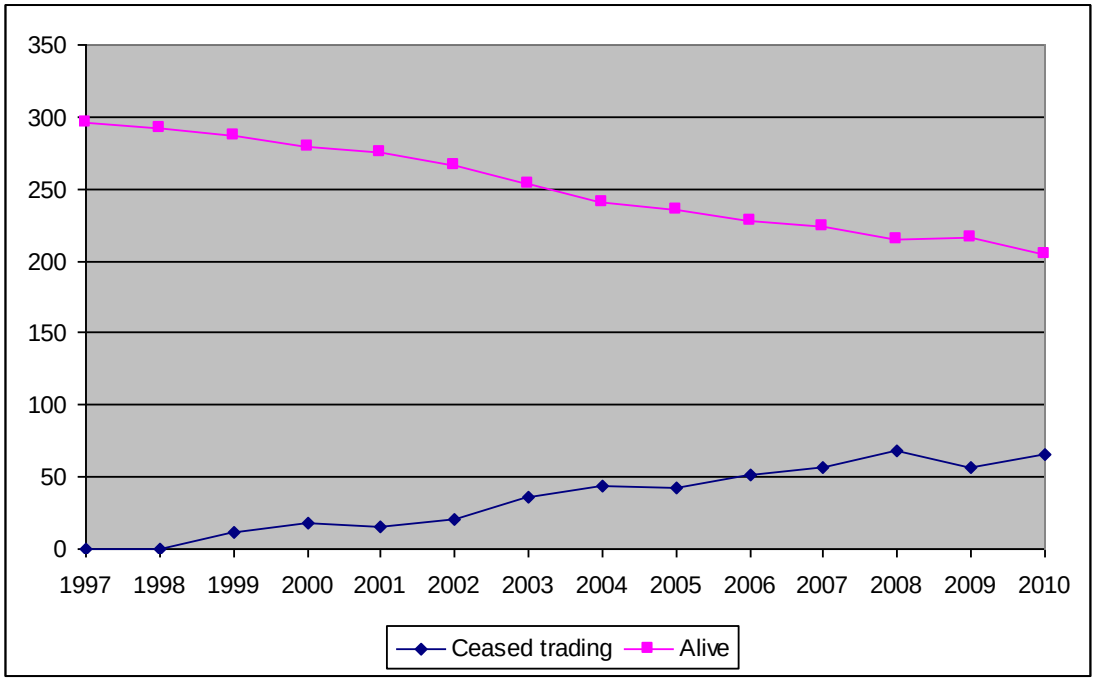


Figure 2: Sales over time period by quantile [Source: ONS]



Descriptive statistics for the survival of firms in the sample are presented in Figure 3 (with more detail in Table 4 in the appendix). These present a very surprising finding that the survival rate of firms in the sample is approximately 76%, even though by 2010 the average firm from the sample was approximately nineteen years old. Given, as discussed in section 2, the expectation that failure for these firms will be quite high, it is surprising to see such a high survival rate, however further examination is required before this figure can be taken at face value, as this figure includes firms that had already been operational long enough to be captured in the sample.

Figure 3 – Total survival by year [Source: ONS]



As a means of investigating this unusually high survival rate we examined the dataset using survival data from FAME, verified by external sources. While FAME suffers from issues with missing data (particularly for performance), it does offer a broader range of potential options beyond the binary definition available in the BSD, allowing us to do some descriptive analysis of firm survival. The results of this are presented in Table 3c below. These results show that approximately half the sample is still

alive or alive after re-incorporating, while most of the firms that are no longer active we dissolved rather than liquidated (though dissolution can come after a firm has entered administration as well). These figures do not necessarily match the BSD results, but these may be explained by the additional two years of trading (BSD survival figures go up to 2010 while FAME goes to 2012) which in difficult economic circumstances increases odds of closing; the inclusion of dormant but technically active companies; and uncertainties around the re-incorporation of firms. The number of acquisitions is fairly low, but there is a possibility that these results may not capture other acquisition deals that may not be captured in the data (potentially using deals for equity, buy-outs, etc).

4. Survival: Factors contributing to firm longevity

Our examination of survival begins with an examination of traditional regression measures of survival, but as discussed above in Section 2 this measure has increasingly been questioned in the literature due to its binary nature and so to address this we use a more nuanced approach to survival that incorporate growth as well, allowing us to gain a clearer picture of the impact of managerial decisions on firm performance.

4.1 Regression analysis of survival

Our analysis of survival begins with OLS and marginal effects logit models for survival as traditionally defined (i.e. activity or inactivity). For this analysis we use two specifications: one involving variables capturing human capital, innovation, market entry, and finance variables, and another keeping key controls and variables from the previous specification but specifically focusing on human capital.

For our regression analysis we focused on methodologies that used several models as means to capture the factors contributing to survival[2]. The first three models, OLS, probit and logit, are all presented in Table 5, and results for the human capital variables are presented in Table 6. Overall there are relatively few factors that are immediately and clearly significant across the different regressions. One common factor across the results is the importance of innovation; firms reporting little or no innovative activity were much more likely to fail, whereas higher R&D intensity in early stages of the firm's life was associated (albeit less strongly) with survival. The human capital analysis also shows positive effects for survival for size of founding team, but negative effects for founders with previous entrepreneurial experience. The results also show significantly decreased probability of survival for firms that had difficulties accessing marketing and sales skills as young firms, and for firms reporting difficulty in accessing R&D skills as those firms reached adolescence.

4.2 Beyond survival: Long-term persistence and thriving among high-tech firms

As we have discussed above, while much of the academic literature on survival uses a binary definition, there is increasing interest in the permutations of survival and its relationship to growth. For instance, is Lovefilm (a company now acquired by Amazon) less desirable than a barbershop if the latter is still operating whilst the former has ceased trading in its prior form? This suggests that survival is not itself intrinsically positive from a growth perspective, and that ceasing to trade is not necessarily negative. This section will provide greater insight into performance dynamics with regard to survival by joining survival and growth data as a means for more nuanced analysis of what makes firms in this sample thrive, and not simply survive.

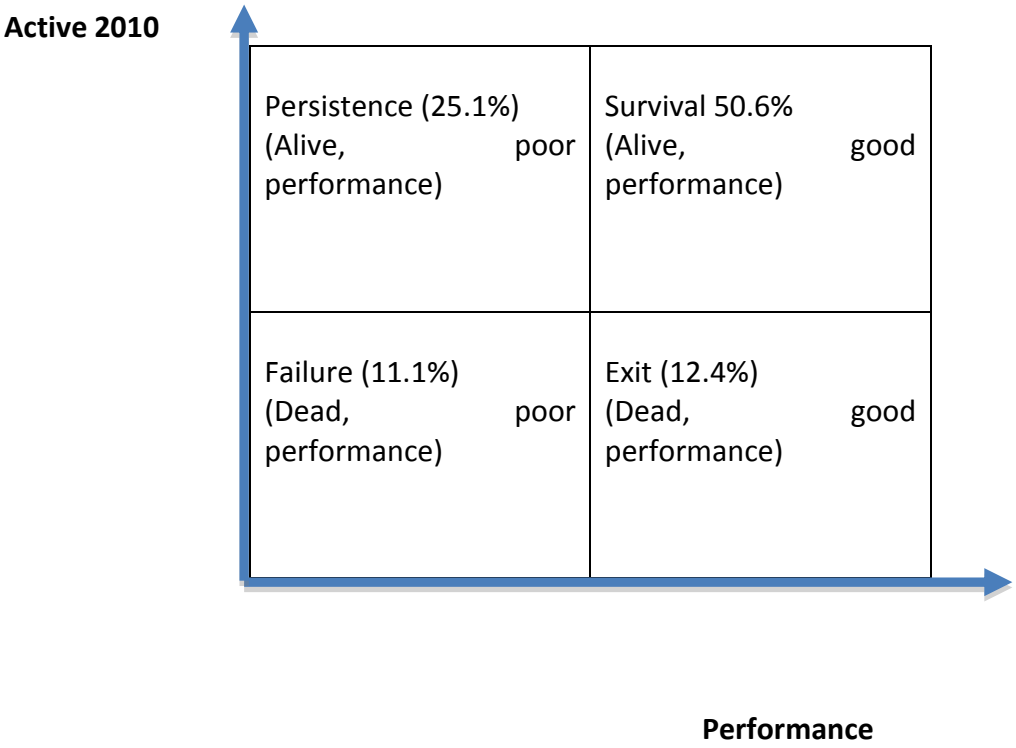
[2] In order to avoid multicollinearity problems, we dropped one instance for series of dummy variables that cumulatively added up to equal one (for instance sector), rotating these as a robustness check.

4.2.1 Framework and Descriptive Statistics

Our method for this section is designed to give us a broader picture on the impact of technology, human capital, and finance on survival and growth. To explore this we use the schematic presented in Figure 4. The schematic has survival (a binary variable, as firms are either coded as being active or not) on the y-axis, and growth on the x-axis; we divide growth into two categories for growth: those whose growth over the period 1997-2010 is above or below the mean of the log growth in employment[3]. The 'active'/'inactive' and 'high'/'low' growth axes allow us to generate a 2x2 matrix of performance. This presents us with four categories: 'Failure' (low performance, inactive: the firm performed poorly and has now ceased to operate); 'Persistence' (low performance, active: the firm has performed poorly but has remained active to 2010); 'Exit' (high performance, inactive: the firm grew but is no longer operational; this may include firms that have been acquired or have been intentionally wound-down by owners); and 'Survival' (high performance, active: firms that have demonstrated growth and general success). In Figure 4 we also present a relative breakdown of the distribution of firms into these four categories. Approximately half the firms fall into the 'Survival' category, with one-quarter in the 'Persistence' category and approximately 12% each fall in 'Failure' and 'Exit' categories.

[3] In addition to these specifications we also experimented with sales growth (instead of employment growth) and different periods of time, and found broadly consistent results, which are available from the authors on request.

Figure 4 – Expanded framework for survival



4.2.2 Methodology

To explore the propensity of AGF sample firms to be in the four categories described above, we used multinomial logit models. Multinomial logit model are based on similar principles to traditional binary logit models, but allow calculation of the relative probability not of one event taking place, but of several. They do this by operating the equivalent of a number of binary models linked together, but in order to generate a coefficient **β** for the complete equation, an additional **β** term is required (Greene 1993); consequently a 'base' value for the equation must be specified. For our analysis, because we have already examined binary survival in depth we use the category 'failure' as the base, instead reflecting the other categories 'Persistence', 'Exit' and 'Survival'. Our models are specified to reflect frequency weighting, and results shown in subsequent sections reflect marginal

effects. These explore the probability that any of the above will happen to a firm, given the other range of possible outcomes for these firms[4].

[4] We have also used individual logit models as a check for this approach and find similar results, available upon request.

4.3 Results

Our analyses for the multinomial logit regressions are presented in Table 7 and are summarised in Figure 5. These models reflect the human capital variables described above and control for sources of finance and other key variables. All show results in terms of relative risk ratio, which gives the relative probability that the unit will increase with a unit increase of the dependent variable. Figure 5 shows factors contributing to the survival, persistence and exit. It shows that persistence is associated strongly with shortages of marketing in initial phases in 1997 and R&D in 2003. It finds some weak impact for size of founding team, overseas education and the share of highly skilled employees. For persistence (low growth, alive) it also finds evidence for VC, angel and government investment in 1997 and angel investment in 2003. For exit (high growth, not alive) it finds size of founding team to have a significant impact, experience of multinationals, a shortage of finance and R&D skills in 2003, and receipt of VC in 1997. For survival (high growth, alive) there is an association with experience in multinationals, education, joint experience of founders, experience founding firms, and concentration of high skill employees. There are also associations with receipt of angel investment in 1997 and 2003.

This section has discussed factors contributing to survival, both in absolute binary terms as well as relative terms relating to growth. We have identified a number of key variables linked both to human capital and to innovation that appear to be associated with survival. In the following section we will shift our focus to growth.

Figure 5 – Summary of Results

Persistence Entrepreneurs General Human Capital (GHC) (founding team size; international education) Managerial Specific Human Capital (SHC) (shortage marketing 1997, shortage R&D 2003) Workers GHC (R&D employment share 1997) Outside HC (start-up equity, public finance, VC)	**Survival** Entrepreneurs GHC (international experience, international education) Entrepreneurs SHC (joint experence Workers GHC (Concentration high skills) Outside HC (start-up equity)
Failure	**Exit** Entrepreneurs GHC (founding team size, international experience) Managerial SHC (shortage finance 2003 and R&D 2003) Outside HC (VC finance at start-up)

5. Growth: Factors contributing to long-run performance

Having examined some general elements of growth as they relate to survival, we now proceed to focus on growth and the impact of the generic and high tech-specific factors discussed in Section 2. This section presents descriptive results, followed by a series of regression analyses examining sales and employment over the periods of analysis.

5.1 Data, method and descriptive statistics

This portion of analysis used the AGF dataset and performance data from FAME and the ONS. Our examination of growth used logs of both sales and employment growth over the full range of our data from 1997-2012, as well as from 2003-2010 (following the second wave of the survey). We also generated annualised growth rates for sales and employment, and also analyse drivers of high growth.

The first part of our analysis examined the relationship between the managerial factors captured in firms in the study and these firms' subsequent growth patterns. For this model we examined the variables listed in Table 1. For this part of our analysis we initially used OLS regressions considering the long-run growth in sales and employment between the last wave of the survey in 2003 and 2010. We use this period as it allows us to generate long-run insights that additional to those seen in the previous examinations of the dataset (for instance Cowling et al 2006 and Coeurderoy et al 2011). The results of these regressions are presented in Tables 8 and 9. These results were further explored by examining the annualised growth rates generated from the AGF detail. This approach allowed us to capture year-on-year rather than net changes. The results of that analysis are presented in Tables 10 and 11.

The second part of the analysis examined the particular drivers of high and low growth within the dataset. The dataset was coded for firms in the 75th, 50th and 25th percentiles[5] for both sales and employment. A series of logit analyses (and quantile regressions for robustness) were then used to examine the factors contributing to the probability of a firm finding itself in a given quartile. These results of the logit analyses are presented in Tables 12 and 13.

[5] We attempted using other quantiles (i.e. 95th and 90th percentile) but the limited sample size meant that despite repeated use of various specifications for both quantile and logit regressions, few meaningful responses could be generated from this period of time.

5.2 Impact of innovation, management and human capital on sales and employment growth

This section will summarise the findings with regard to drivers of long-term and annual growth among the AGF dataset. We begin our discussion by considering the figures for long-term change in employment in Table 8; for these results, standard errors are clustered at the firm level. This table presents the net change in employment between 2003 and 2010. The results for employment show negative associations between employment growth and founder team size, and initial receipt of VC and angel investment. The sales growth figures show a negative association with initial receipt of VC and angel investment (the latter being the only common result) and a strongly positive result for firms that had acquired their technology from external sources.

These results are augmented by the sales and employment regressions for human capital variables presented in Table 9. This shows regressions for sales and employment growth for the human capital variables over the 1997-2010 time period. There is a negative growth association for founding team for employment growth, and negative association with education abroad for growth, but both of these are relatively weak effects. On the surface this might suggest that there is little evidence of interesting effects, but these results only provide an aggregate portrait of the factors contributing to growth. Consequently these may miss some of the key fluctuations that appear when annualised growth rates are considered. Therefore we examined annualised growth rates using the annual sales and employment figures from 1997-2010. Because the results capture data and 1997 and 2003, we then disaggregated the annualised growth rates for annual growth rates between 1997-2003 (when the first wave of observations would be valid but the second would not because they had not been recorded yet) and 2003-2010 (when both would be valid).

The results for annualised employment growth are presented in Table 10; for these results standard errors are clustered at the firm level. In aggregate we find a number of significant effects. Some control factors, such as age and initial size, were significant. With regard to our hypotheses, we find small but strong associations with early R&D intensity for annual growth. For our examination of targeting of markets, we find strong positive annual growth for firms that have entered international markets, with some negative results for those firms producing capital and consumer goods. We find limited evidence of impact from the human capital variables, although there are some indications that firms started by new entrants had higher growth. For finance we also find negative annual growth for firms receiving VC, angel and grant investments; this is an unexpected result that we will address in more detail in the following section. Our breakdown of the annualised growth rates for the periods of the survey generally echo these results, suggesting consistency in the results over time.

A similar approach was used to examine sales. Again following our hypotheses, we see small but significant improvements in growth in sales associated with R&D intensity. We again find strong associations between annual growth and entry of international markets. For human capital factors we find similar positive effects for founding team size and new entrants to the market. Our previous negative results for VC, angel and grant funding were echoed in the sales figures as well. Again the results were generally upheld across different time periods from the study.

5.2.1 Drivers of high performance

While the results summarised in section 5.2 present some insights into the characteristics and nature of growth in the firms from the AGF sample, we also consider factors contributing to particularly high levels of growth in our sample. To do this, we conducted a series of examinations of quantile regressions on the top and bottom quartiles of growth for employment and sales.

The figures for employment and sales are presented in Table 12. These show some mixed results, including findings for negative associations with high growth for firms receiving grants, positive association with international sales and firms started by new entrepreneurs, and employment size. We generate mixed findings for age, which suggests that the effects captured elsewhere in our analysis may be more explicative than a strict quantile approach. Our analysis is particularly hamstrung by the low sample size and the relative simple specifications we are able to use for this analysis.

6. Discussion

Following the summary of results from the discussion above, we now move to discuss the aggregate results of our analysis and draw some conclusions from the analysis into the long-run performance of firms from the AGF dataset. Our discussion will be based around the main themes and hypotheses discussed in Section 2.

6.1 Human capital

Our previous discussion of human capital loosely categorised our areas of interest as entrepreneur-level and managerial/employee-level human capital and, within the topic of human capital, general human capital (i.e. skills that are relevant to any industry) and specific human capital (i.e. skills relevant to the particular industry in which the firm is based). Our hypotheses 1 and 2 suggested that access to human capital from both entrepreneurs and employees was key for long-run growth and survival, and our results generally support this, while giving us some nuanced insights into the importance of these processes.

For entrepreneurs, we find evidence that entrepreneurs' general human capital plays a key role in firm survival and performance. In particular, international experience and education seem to be associated with the decision to expand overseas, which itself is associated with higher levels of growth. In particular,

experience working overseas is associated with long-run growth, suggesting that familiarity with non-UK markets helps entrepreneurs to be more comfortable with potential expansion. There is also some evidence of specific human capital being helpful for entrepreneurs – those with experience working with others in their industry are associated with long-run survival and growth. Together we can interpret these findings to suggest that entrepreneurs with a range of professional experiences are more likely to be able to utilise their experience to the benefit of their companies.

While our findings regarding the importance of entrepreneurial human capital are perhaps expected, our results regarding managerial/worker human capital are more striking. We find that 40% of firms report difficult in accessing marketing or production skills, and these are more likely to fail to grow in the long-run, years after these skills shortages were reported. In particular, firms reporting difficulties in finding marketing staff had lower growth than those that did not report these problems. In contrast, the firms that survived and showed higher growth did not report significant skill shortages. This suggests that these firms were able to develop products and markets without impediment by resource constraints. Among firms showing high growth, there were considerable differences between those firms that had ceased trading and those that were still operational. While the firms that are still trading reported no skill shortages, those that eventually exited reported shortages in financial skills and R&D management. These shortages could potentially explain managers' decisions to close the company or sell it to another company – if the company is unable to raise finance and is unable to access the skills it requires to engage in R&D, the necessity for innovation and cost of innovating could then make exit (particularly by acquisition) an attractive prospect. The finding that firms reporting higher concentration of skilled workers were more likely to be survive reinforces this potential explanation; if a firm must engage in R&D to survive but lacks both capital and R&D management skills, this presents a potentially intractable problem that could conceivably result in the sale or closure of the firm, even if it had demonstrated high growth. On this basis we may conclude that we can confirm

Hypothesis 4, although the results are more nuanced than we might otherwise expect.

6.2 Innovation and Technology Strategy

Our previous brief review of the innovation literature discussed widely documented importance of innovation for firm survival. Our research in this area generally affirms our first hypothesis about the importance of innovation, particularly in the early years of a firm's life. We find that 36.5% of firms develop their core technologies internally, which suggests potential for new innovations. We find that firms that did not engage in innovative activity in their early years (as observed in 1997) were more likely to exit over the 13-year period of observation. Furthermore, early investment in R&D was widely associated with sales and employment growth over the long-run. These results, constant across models, suggest that for the firms in our sample, investment in innovation allowed the firms to maintain their competitive advantage and to continue to grow. Beyond this, our results show that management of the innovative process remains crucial to how firms succeed.

Our examination of the importance of skills relative to performance and survival shows that the absence of R&D management skills was a factor differentiating the most successful firms (active and high growth) from those that had exited the market or had not shown high growth. For each point of percentage of graduates employed, the probability of long-term growth increased by 2.4%. For a small firm, being able to hire graduates has the potential to make an enormous difference in terms of long-run performance. Among firms that 'persisted' (i.e. survived but showed low growth), the firms invested in R&D employment but a reported lack of managerial skills for research. This suggests that while the will for investment may have been present for these firms, the ability to harness the investment may have been lacking. In contrast, firms that had 'exited' (i.e. showed high growth but were no longer active) reported shortages in R&D management skills as well. Tellingly, the

firms that were active and high growth did not have this problem. These findings potentially explain the weak positive association for R&D activity among firms in the lowest performance quartile; while innovation is crucial for success, long-term growth comes from having sufficient management structures in place to manage innovative activities and ultimately appropriate returns from that investment in innovation.

6.3 Market targeting

Another key area captured by our data was related to product positioning and implications of decisions to target international markets. Our results present strong evidence that firms that made the decision to enter overseas markets early in their lives (as measured in 1997) were more likely to survive and to grow, by most measures. Two-thirds of the firms in our sample were targeting overseas markets at start-up, and this proves to be crucial for survival and growth. This represents an extension of previous work on the dataset (i.e. Coeurderoy et al 2011), suggesting that the initial decision to look overseas for markets yields long-run benefits for the firms that enter those markets. These findings produce some interesting and relevant questions about whether moving into an international market is a sign of quality management or if the additional market 'pulls' the firm to higher performance. Ultimately this represents an interesting question that raises potential endogeneity issues, which are important and relevant but which would require some different analysis to fully bring us to a satisfactory conclusion. On the aggregate there is sufficient evidence to support Hypothesis 4 and to conclude that there is a positive association between internationalisation and long-run growth.

Further to this main finding, we find mixed evidence about the targeting of other markets. There is some evidence of higher growth for firms involved in the production of components compared to the production of capital or consumer goods, but this finding is only found in annual growth and not in the long-run results.

It could perhaps be hypothesised that this finding (if validated) reflects changes in global supply chains and the potential for firms to find larger markets in these supply chains, while consolidation of consumer markets has been more difficult. However this remains speculative and grounds for future examination elsewhere.

6.4 Funding

Our analysis of funding examined the long-run implications for growth and survival for firms that had received government grants, angel investment and venture capital investment over the long run. We find that angel investment is twice as common as venture capital investments. Our results are rather surprising. While we find that firms receiving angel investment at start-up are three times more likely to survive, we also find consistent, significant evidence that firms that had received grants, angel investment and VC all showed significantly lower growth levels over the long term. The negative results are consistent across the 1997-2003 time period. We also find less clear-cut evidence that firms that had received VC and angel investment (and to a lesser extent grants) at the time of the second wave of the survey had higher levels of growth.

These results are surprising but perhaps not as controversial as they might otherwise appear. The poor performance of firms receiving grants may be explained by the fact that firms seeking grants may already be financially constrained when they seek this aid, and thus may show subsequent poor performance. Further, our examination of growth and survival shows that access to equity finance at start-up is generally associated with high growth. We also know from numerous studies (among them Murray and Mariott 1998 and Siepel 2012) that IPOs are not a widely viable form of exit for UK equity investors. Instead, acquisitions or trade sales are by far the most common means of exit in the UK. This implies that successful firms receiving equity investment are incentivised to seek acquisition as a form of exit, leaving those that are less successful remaining in the market. Recent work has given evidence that equity-backed firms that are not massively successful tend not

to fail immediately, but instead persist, performing as if they had not received investment in the first place (Coad and Siepel 2012). The long-term poor performance of VC and angel-back investments could be a case of this, with high-performing firms exiting early while the firms that received funding but were less successful persist in slow decline. Ultimately we are not able to accept our hypothesised link between grant funding or equity investment and growth and survival, but we suspect this may be a manifestation of the UK's broader financing structure.

6.5 Trajectories of growth

Taken as a whole, the results presented above suggest that there are distinct paths available to firms, and that these paths highlight commonalities with existing literature. For instance, firms that are active but show low growth are characterised by a skilled workforce, large founding teams and financial resources, but suffer from lack of experience and shortages in key areas, particularly in terms of finding markets for technically advanced products and developing these products further. Importantly, these initial shortfalls have a meaningful long-run impact on the growth and survival of the firms in our sample.

By contrast, the firms that have exited have several of the hypothesised factors behind growth firms – they have large founding teams and international experience, as well as VC. These companies remained successful until exiting. The evidence that these were lacking some key elements of managerial human capital regarding finance and R&D suggests two possibilities for these firms: either they explicitly always intended for growth and quick exit; or that they were able to grow and reach a certain size, but were faced with financial and innovation barriers that prevented them from scaling their growth. Either way, these should not be considered 'failures' as such (as they would be in the traditional 'survival' literature), seeing that they represented firms that were successful, if not necessarily long-lived.

In contrast, our classification of active and high growth firms presents a picture of firms with considerable levels of experience and skills, and access to required human capital. This seems to suggest that these firms feature professional managerial teams who have good understanding of the requirements of their markets and have sought out the appropriate skill sets and human capital to bring their business plan to action. In this way these firms have been able to grow and succeed, thriving over an extended period of time by drawing upon experience and skills to generate competitive advantage.

7. Conclusion

The growth and success of high technology firms is of crucial importance to the UK economy, and this study has explored the long-run impact on growth of a number of key factors, including human capital, R&D and technology strategy, market decisions and financing. This paper has examined the performance and survival of the unique longitudinal data from two Anglo German Fund surveys of UK firms, using data from the UK Business Structure Database and the FAME database to present a truly novel perspective on the very long-term (i.e. 15-20 years) growth implications of managerial decisions on a sample of high-tech UK firms. We therefore are able to use the incredibly rich level of detail on these firms at three observation points approximately fifteen and nine years ago to gain understanding of factors contributing to the long-run growth and survival of high tech firms.

Our results generally affirm some factors widely accepted in the academic literature, for instance the considerable importance for long-run growth of ongoing investment in innovation, entry into international markets and entrepreneurs' human capital. However we also make two major unique contributions that provide new insight into the long-run growth prospects of high-tech firms.

Our first contribution highlights the importance of access to skills for high-tech firms when they are young. We find that the nearly 40% of firms reporting difficulty accessing skills had lower long-run growth than those not reporting that problem. This is an important finding in that it suggests a long-term negative effect on firms that are constrained by access to skills, particularly with regard to marketing and R&D. If these firms are unable to find markets for their products or sufficiently develop new products in early stages of the firm's life, these force firms into actions that prevent them from reaching their long-term potential. In a sense this finding echoes the widely recognised effects of unemployment: there is considerable evidence that for individuals a period of unemployment gives a 'scarring' effect on that person's future employment and earnings prospects (see Jacobson et al 1993, Arulampalam 2001). Our results suggest a similar effect for firms: those firms that are unable to find employees with key skills in early stages suffer lifelong performance deficits compared to other firms.

Our second contribution relates to our understanding of survival and firm 'success'. In line with recent empirical research challenging the prevailing understanding that survival is necessarily good and closure is necessarily bad, we have provided an insight into this by highlighting the sizeable proportion of firms that have continued operation over twenty years, but have generated little growth. We then contrast these with firms that showed high growth but then ceased trading. Of these firms, a number were eventually acquired, while others ceased trading for reasons unknown. We do know that firms that showed high growth but eventually exited reported shortages of finance and R&D staff. While we know that the absence of a widespread IPO market makes acquisition the most desirable form of exit, we find that only some firms who showed high growth before ceasing trading were in fact acquired. Consequently we conclude that there exist high growth firms whose ongoing existence is curtailed by certain barriers to skills. From a policy perspective, the targeting of firms that are high growth but report skills shortages is a legitimate and useful ultimate policy outcome. In this way our finding echo Lee (2011), whose work identifies management skills as one of the significant issues facing high-growth firms.

This policy conclusion may also be related back to our other major finding about the role of skills. Much as the incentives available to funders shape firms' strategies and paths to growth, so too does the availability of appropriate skills and resources. Our research highlights the crucial role that employees' skills play in the long-run performance of the firm. Those firms that are unable to access the skills required to market and develop their products suffer long-term growth implications. Consequently we may conclude that investment in the skills base is a reasonable policy measure to encourage the long-run performance of high-tech firms. Access to skilled workers gives firms the opportunity to develop strategies that are not restricted by access to human capital and thus (one may hypothesise) are more ambitious.

In making these conclusions, it is important to recognise the restrictions and limitations of our data and the analysis of the work we have done here. Our data provides a very unique perspective on a number of long-range managerial and human capital factors impacting on firm performance and survival, however there are limitations to what our data can actually capture. For instance, our performance data begins in 1997 so we are unable to clearly identify firms' growth prior to this date (apart from our control for firm size at founding). Consequently there is the possibility that the firms that were unable to access sufficient skills may have done so because they were not high-quality firms from the start, and that their inability to recruit and to grow was indicative of a lack of 'quality', and these firms' long-run survival may have been due to luck or lock-in within the industries. However it remains very difficult to quantify a hypothesis along these lines, not least for the lack of a sufficient proxy measure for quality beyond those that we have measured. There remains a prospect of endogeneity among these human capital and performance variables that persists due to the interconnected nature of the entrepreneurial process.

Similarly we must accept with caution our conclusions about the impact of firm financing structures on performance. Our interpretation of our results that

successful equity-backed firms exited and ceased trading independently while unsuccessful equity-backed firms persisted with poor performance is generally supported with the data that we have. Two alternate explanations exist, but there is insufficient support to accept these. The first is simply that VC and angel investment results in lower performance for firms. This possibility is contrary to literature (for instance Puri and Zarutskie 2008 and Jackson et al 2011) and while there is some evidence that some UK VC funds are effectively only associated with negative returns (namely the Regional Venture Capital Funds scheme, as discussed in Nightingale et al 2009), this explanation seems unlikely. Further, we lack sufficiently fine-grained data about the background of investors to be able to draw any further conclusion. In addition, while we were able to conduct some background analysis using FAME, it was impossible to collect clear data on the ultimate outcomes of firms, and even more difficult to link it to survival. Consequently we are required to present a fairly conditional interpretation of our findings, and while our findings fit this framework there is more work that could be done to explore this further in the future.

The research and data presented here provide a range of potential topics for future research. There is considerably more work to be done exploring and further validating our two main findings, and there remain other aspects of the dataset that remain to be explored in more detail, particularly around the relationship between technology and competition, and the drivers of change over time. On a broader scale we are currently preparing to run the survey again, which will provide a third wave of managerial data and will give a more detailed longitudinal perspective on firm performance.

In conclusion, this paper has explored the long-run impact of a number of managerial factors on the long-run performance of high-tech firms. Following the performance of a cohort of firms as they approach twenty years in business, we find evidence that access to resources in the early stages of these firms' lives contributes significantly to their long-run performance. Firms that are able to access sufficient skills to develop and market their products demonstrate superior long-run

performance. We also conclude that firms' funding environments play key roles in shaping their strategic decisions and performance over the long term. By highlighting these points, we emphasise that the actions taken now by policymakers have long-lasting effects of firms in the economy, and that the availability of resources and the way in which these are used have the potential to create dividends running much longer than previously understood.

References

Acs, Z. and Audretsch, D. (1988). Innovation in large and small firms: An empirical analysis. American Economic Review 78:4 pp. 678-6900.

Adams, R., Bessant, J. and Phelps, R. (2006). Innovation management measurement: A review. International Journal of Management Reviews 8:1 pp. 21-47.

Agarwal, R. (1998). Small firm survival and technological activity. Small Business Economics 11:3, pp. 215-224.

Almus, M. and Nerlinger, E. (1999). Growth of new technology-based firms: Which factors matter? Small Business Economics 13:2, pp. 141-154.

Arulampalam, W. (2001). Is unemployment really scarring? Effects of unemployment experience on wages. Economic Journal 111, pp. F585-F606.

Blundell, R. et al., (1999). Human Capital Investment: The Returns from Education and Training to the Individual, the Firm and the Economy. Fiscal Studies, 20(1), pp.1–23.

Brander, J. Amit, R., and Antweiler, W. (2002). Venture capital syndication: Improved venture selection vs the value added hypothesis. Journal of Economics and Management Strategy, 11:3, pp. 432-456.

Bürgel, O. (1999) 'The internationalisation of British start-up companies in high-technology Industries'. Unpublished doctoral dissertation, Coventry: Warwick Business School, University of Warwick.

Bürgel, O., Fier, A., Licht, G. and Murray, G. (2001) The Rapid Internationalisation of High- Tech Young Firms in Germany and the United Kingdom. London and Berlin: Anglo-German Foundation.

Bürgel, O., Fier, A., Licht, G. and Murray, G.C. (2004) 'The internationalisation of young high-tech firms'. ZEW Economic Studies, 22, Heidelberg and New York.

Butchart, R. (1987) 'A new UK definition of high-technology industries'. Economic Trends, 400: 82–8.

Caves, R.E., (1998). Industrial Organization and New Findings on the Turnover and Mobility of Firms. Journal of Economic Literature, 36(4), pp.1947–1982.

Cefis, E. & Marsili, O., (2011). Revolving doors: entrepreneurial survival and exit. Journal of Evolutionary Economics, 21(3), pp.367–372.

Coad, A. (2009) The Growth of Firms: A Survey of Theories and Empirical Evidence. London: Edward Elgar.

Coad, A. (2010). Exploring the processes of firm growth: Evidence from a vector auto-regression. Industrial and Corporate Change 19:6, pp. 1677-1703.

Coad, A., Frankish, J., Roberts, R. and Storey, D. (2012) Growth paths and survival chances: An Application of Gambler's Ruin Theory. Journal of Business Venturing, forthcoming. DOI: 10.1016/j.jbusvent.2012.06.002

Coad A, Siepel J (2012). Make or break: the distribution of causal impacts of venture capital on firm performance. Paper presented at the Babson College Entrepreneurship conference, Texas Christian University.

Coeurderoy, R. and Murray, G.C. (2005) 'Institutional environments and the location decisions of start-ups: Evidence from the first international market entries of new technology-based firms'. Working paper, School of Business and Economics, University of Exeter.

Coerderoy, R., Cowling, M., Licht, G., Murray, G. (2011). Young firm internationalization and survival: Empirical tests on a panel of 'adolescent' new technology based firms in Germany and the UK. International Small Business Journal. In press: doi: 10.1177/0266242610388542

Colombo, M.G. & Grilli, L., (2005) Founders' human capital and the growth of new technology-based firms: A competence-based view. Research Policy, 34(6), pp.795–816.

Colombo, M.G. & Grilli, L., (2010) On growth drivers of high-tech start-ups: Exploring the role of founders' human capital and venture capital. Journal of Business Venturing, 25(6), pp.610–626.

Cowling, M. (2006). Early stage survival and growth. In Parker, S. (ed.) Handbook of Entrepreneurship Research: The life cycle of entrepreneurial ventures pp. 477-504.

Cowling, M.; Fryges, H.; Licht, G.; and Murray, G. (2006) "Survival of new technology based firms in the UK and Germany,"Frontiers of Entrepreneurship Research: Vol. 26: Iss. 22, Article 2.
Available at: http://digitalknowledge.babson.edu/fer/vol26/iss22/2

Czarnitzki, D. and Licht, G. (2006). Additionality of public R&D grants in a transition

Deeds, D. (2001). The role of R&D intensity, technical development and absorptive capacity in creating entrepreneurial wealth in high technology start-ups. Journal of Engineering and Technology Management 18:1 pp. 29-47.

Delmar, F. and Shane, S. (2006). Does experience matter? The effect of founding team experience on the survival and sales of newly founded ventures. Strategic Organization 4:3 pp. 215-247.

Denis, D. (2004). Entrepreneurial finance: An overview of the issues and evidence. Journal of Corporate Finance 10:2 pp.301-326.

Eisenhardt, K. and Schoonhoven, C. (1990). Organizational growth: Linking founding team, strategy, environment, and growth among US semiconductor ventures 1978-1988. Administrative Science Quarterly 35:3 pp. 504-529.

Fontes, M. and Coombs, R. (1997). The coincidence of market and technology objectives in new technology based firms. International Small Business Journal 15:4 pp.14-35.

Freel, M. (2003). Sectoral patterns in small firm networking, innovation and proximity. Research Policy 32:5, pp. 751-770.

Freel, M. (2005). Perceived environmental uncertainty and innovation in small firms. Small Business Economics 25:1, pp. 49-64.

Fryges, H. (2005) 'The change of sales modes in international markets – Empirical results for German and British high-tech firms'. ZEW discussion paper no. 05-82, Mannheim.

Fryges, H. (2006) 'Hidden champions – How young and small technology-oriented firms can attain high export-sales ratios'. ZEW discussion paper no. 06-045, Mannheim.

Lee, N. (2011). Free to grow? Assessing the obstacles faced by actual and potential high growth firm. NESTA Working Paper. London: NESTA.

Leung, A. (2003). Different ties for different needs — recruitment practices of entrepreneurial firms at different developmental phases. Human Resource Management 42:4, 303–320.

Li, Y. and Atuahene-Gima, K. (2001). Product innovation strategy and performance of new technology ventures in China. Academy of Management Journal 44:6 pp. 1123-1134.

Mason, C. and Harrison, R. (2002). Barriers to investment in the informal venture capital sector. Entrepreneurship and Regional Development 14:3 pp. 271-287.

Meyer, M. and Roberts, E. (1986). New product strategy in small technology-based firms: A pilot study. Management Science 32:7 pp. 806-821.

Moneta, A., Entner, D., Hoyer, P. Coad, A. (2012). Causal inference by independent component analysis with application to macro and micro-economic data. Oxford Bulletin of Economics and Statistics, forthcoming.

Murray, G. and Lott, J. (1995). Have venture capitalists a bias against new technology-based firms? Research Policy 24:2 pp.238-259.

NESTA (2006) The Innovation Gap. London: NESTA

Nightingale, P. and Coad, A. (2011). Muppets and Gazelles: Ideological and methodological biases in Entrepreneurship Research. Industrial and Corporate Change, forthcoming with revisions.

Nightingale, P., Murray, G., Cowling, M., Baden-Fuller, C., Mason, C., Siepel, J., Hopkins, M. and Dannreuther, D. (2009). From funding gaps to thin markets: UK government support for early stage venture capital. London: NESTA.

Prowse, S. (1998). Angel investors and the market for angel investments. Journal of Banking and Finance 22:6-8 pp.785-792.

Sapienza, H., Autio, E., George, G. & Zahra, S. (2006) The Effect of Early Internationalization on Firm Profitability and Growth. Academy of Management Review, 62:4 pp. 914-933.

Siegel, D., Wessner, C. Binks, M. and Locket, A. (2003) Policies promoting innovation in small firms: Evidence from the US and UK. Small Business Economics 20:2 pp. 121-127.

Stam, E. and Wennberg, K. (2009). The roles of R&D in new firm growth. Small Business Economics 33:1 pp. 77-89.

Storey, D. and Tether, B. (1998). New technology based firms in the European Union: An introduction. Research Policy 26:9, pp. 933-946.

Tidd, J. and Hull, F. (eds) (2003). Services Innovation: Organisational responses to technological and market imperatives. London: Imperial College Press

Verhees, F. and Meulenberg, M. (2004). Market orientation, innovativeness, product innovation and performance in small firms. Journal of Small Business Management 42:2, pp. 134-154.

Wallsten, S. (2000). The effects of government-industry R&D programs on private R&D: the case of the Small Business Innovation Research program. RAND Journal of Economics 31:1 pp. 82-100.

Zahra, S. and Bogner, W. (2000). Technology strategy and software new ventures' performance: Exploring the moderating effect of the competitive environment. Journal of Business Venturing 15: 2 pp. 135-173.

Zahra, S. A., Ireland, R. D. and Hitt, M. A. (2000) International expansion by new venture firms: international diversity, mode of market entry, technological learning and performance. Academy of Management Journal, 43 (5). 925-950

Table 1: List of variables

Variable	Definition and year of observation (* = binary variable)
Human capital and survival	
nbr_founders	Number of founders
new_entr	New entrepreneur*
exp_abroad	Work experience abroad*
exp_intl_work	Work for international firm*
edu_abroad	Education abroad*
founder_joint	Founder joint experience*
exp_ent	Experienced entrepreneur*
skilled_staff_pct	Percentage high skill employees 1997
skilled_tech_staff	People with technical expertise 1997
rd_employees	Number of R&D employees 1997
short_marketing_97	Shortage marketing skills 1997*
short_ marketing_03	Shortage marketing skills 2003*
short_sales_97	Shortage sales skills 1997*
short_ sales_03	Shortage sales skills 2003*
short_finance_97	Shortage finance skills 2003*
short_ finance_03	Shortage finance skills 2003*
short_research_97	Shortage R&D skills 2003*
short_ research_03	Shortage R&D skills 2003*
Technology and R&D	
tech_combine	Technology is a new combination of technologies 1997*
tech_external	Technology is novel but developed elsewhere 1997*
tech_internal	Technology is novel and developed internally 1997*
rd_never	Never does R&D 1997*
rd_occasional	Occasionally does R&D 1997*
rd_always	Permanently doing R&D 1997*
rd_intensity	R&D intensity 1997
Market Targeting	
prod_capgood	Product is a capital good or service*
prod_consumer	Product is a consumer good or service*
prod_component	Product is a component*
intl_intend	Intention to sell abroad at founding*
intl_sales	Selling internationally 1997*
Finance	
vc_97	Received VC in 1997*
vc_03	Received VC in between 1997-2003*
angel_97	Received angel investment in 1997*
angel_03	Received angel investment between 1997-2003*
gra_97	Received grant in 1997*
grant_03	Received between 1997-2003*
Controls	
sector_software	Firm is in software or IT services sector*
sector_hardware	Firm is in IT and communications hardware sector*
sector_eng	Firm is in engineering sector*
sector_lifesci	Firm is in biomedical and life sciences*
emp_startup	People employed at founding
age	Age from 2010 (natural log)

Table 1a – Variable description

Variable	Mean	Std. Dev.
nbr_founders	2.227273	1.390354
vc_97	0.0824916	0.2753441
vc_03	0.1026936	0.3038141
angel_97	0.1616162	0.3684086
angel_03	0.1801347	0.3846235
grant_97	0.1986532	0.3993226
grant_03	0.2138047	0.4103361
prod_capgood	0.4048866	0.491299
prod_consumer	0.1151832	0.3195219
prod_component	0.2687609	0.4437027
tech_combine	0.344523	0.4756328
tech_external	0.1766784	0.3817337
tech_internal	0.3657244	0.4820587
sector_software	0.2828283	0.4507533
sector_hardware	0.2020202	0.4018456
sector_eng	0.1582492	0.3652821
sector_lifesci	0.0909091	0.2877221
new_entr	0.8307953	0.3752503
intl_intend	0.6234676	0.4849408
intl_sales	0.6683502	0.4712027
rd_never	0.1568297	0.3639471
rd_occasional	0.2748735	0.4468274
rd_always	0.5682968	0.4957317
empd_sh	22.44874	23.92365
exp_abr	0.4393939	0.4967316
exp_mult	0.4545455	0.4983493
edu_abroad	0.1447811	0.3521766
skilled_staff_pct	35.58677	30.54391
short_marketing_97	0.4040404	0.4911189
short_marketing_03	0.2525253	0.434827
short_sales_97	0.3973064	0.4897528
short_sales_03	0.2828283	0.4507533
short_finance_97	0.3249158	0.4687381
short_short_finance_03	0.1851852	0.3887751
short_productivity_97	0.4040404	0.4911189
short_productivity_03	0.2525253	0.434827
short_research_97	0.2912458	0.4547194
short_research_03	1	0
skilled_tech_staff	6.563973	10.47603
rd_employees	4.243919	9.63845
founder_joint	0.5286195	0.499601
exp_ent	0.6228956	0.4850699

Table 2 – Employment Change Descriptive Statistics

	Log Employment Change 2003-2010	Log Sales Change 2003-2010
Mean	-0.144	-0.030
N	3570.000	3542.000
Std Dev	0.984	1.171
Variance	0.968	1.372
Std Error	0.016	0.020
Skewness	-1.795	-1.225
Kurtosis	7.871	6.493
10% quantile	-1.099	-1.307
25% quantile	-0.405	-0.522
Median	0.000	0.101
75% quantile	0.357	0.643
95% quantile	1.075	1.508

Table 3a - Descriptive Statistics for AGF Employment by Year [Source: ONS]

	N	Mean	Median	Std Dev	Variance	Std Error	Skewness	Kurtosis
1997	296	37.578	6	264.799	70118.520	15.391	13.560	202.322
1998	292	40.086	7	279.460	78097.660	16.354	12.865	180.773
1999	299	44.742	7	302.483	91496.120	17.493	12.684	175.467
2000	297	45.778	7	300.908	90545.420	17.460	12.543	169.980
2001	291	51.306	7	337.999	114243.100	19.814	12.664	175.593
2002	286	51.273	12.5	272.917	74483.720	16.138	11.131	133.656
2003	289	59.412	12	298.170	88905.040	17.539	10.190	115.521
2004	285	61.189	13	299.756	89853.530	17.756	10.122	114.272
2005	278	62.482	13	302.196	91322.420	18.125	9.558	101.045
2006	280	63.643	12	306.960	94224.220	18.344	9.368	98.294
2007	281	66.068	12	338.545	114612.400	20.196	9.708	103.308
2008	283	85.965	12	609.719	371757.500	36.244	13.178	190.341
2009	272	81.305	12	516.766	267047.000	31.334	11.809	153.486
2010	271	77.129	11	482.162	232480.200	29.289	11.611	148.689

Table 3b Descriptive Statistics for AGF Sales by Year [Source: ONS]

	N	Mean	Median	Std Dev	Variance	Std Error	Skewness	Kurtosis
1997	296	3573.774	500	30652.46	9.40E+08	1781.638	14.989	239.787
1998	292	4300.062	591.5	31708.12	1.01E+09	1855.577	13.835	211.661
1999	299	5164.344	745	39671.23	1.57E+09	2294.247	14.617	232.493
2000	297	5378.673	838	39104.91	1.53E+09	2269.097	14.562	230.784
2001	291	3373.928	820	13360.71	1.79E+08	783.219	9.098	97.040
2002	286	6091.703	904.5	36504.53	1.33E+09	2158.558	12.259	170.707
2003	289	6068.616	834	34047.05	1.16E+09	2002.768	11.566	154.285
2004	285	6651.256	878	37627.43	1.42E+09	2228.857	11.136	142.045
2005	278	6716.806	944.5	38000.47	1.44E+09	2279.116	11.053	139.556
2006	280	6105.286	986	35844.47	1.28E+09	2142.117	13.370	199.927
2007	281	8089.943	993	44647.67	1.99E+09	2663.457	10.337	123.031
2008	283	9676.117	1000	64494.06	4.16E+09	3833.774	13.147	193.034
2009	272	9865.471	1062.5	65276.26	4.26E+09	3957.955	13.165	193.137
2010	271	10243.06	959	70745.57	5.00E+09	4297.487	13.419	199.219

Table 4 – Summary of active firms in AGF sample by year [Source: ONS]

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Inactive	0	0	12	18	15	20	36
Active	296	292	287	279	276	266	253
Total	296	292	299	297	291	286	289

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Inactive	44	42	52	57	68	56	66
Active	241	236	228	224	215	216	205
Total	285	278	280	281	283	272	271

Table 4a – Outcomes of firms from sample [Source: FAME]

Status	**Number**
Active	130
Active (re-incorporated)	22
Acquired	7
Dormant	14
Dissolved	106
Dissolved (re-incorporated)	27
Liquidated	32

Table 5 OLS and Logit for Survival [Source: ONS]

	OLS for Survival			**Logit for Survival**		
	Coef.	Rob SE	P>t	Coef.	Rob SE	P>z
nbr_founders	0.03	0.023	0.2	0.227	0.188	0.226
vc_97	-0.077	0.134	0.565	-0.577	0.760	0.448
vc_03	0.014	0.116	0.904	0.114	0.725	0.875
angel_97	-0.136	0.135	0.315	-0.867	0.672	0.197
angel_03	-0.045	0.108	0.679	-0.213	0.658	0.747
grant_97	0.09	0.092	0.328	0.554	0.651	0.395
grant_03	-0.021	0.089	0.813	0.033	0.550	0.951
prod_capgood	0.058	0.068	0.397	0.39	0.449	0.385
prod_consumer	-0.101	0.115	0.38	-0.665	0.648	0.305
prod_component	0.028	0.075	0.712	0.216	0.456	0.637
tech_combine	-0.072	0.067	0.283	-0.415	0.368	0.259
tech_external	-0.109	0.083	0.191	-0.613	0.451	0.174
tech_internal	-0.075	0.075	0.316	-0.472	0.432	0.275
sector_software	-0.128	0.101	0.207	0.041	0.599	0.945
sector_hardware	-0.217**	0.110	0.049	-0.496	0.563	0.378
sector_eng	-0.136	0.117	0.247	0.094	0.676	0.889
sector_lifesci	(omitted)			1.075	0.842	0.202
ind_5	-0.119	0.118	0.316	(omitted)		
age10	-5.855	24.750	0.813	-55.638	146.505	0.704
new_entr	0.18	0.122	0.141	1.188**	0.601	0.048
lnWindow	-0.016	0.043	0.708	-0.111	0.252	0.659
intl_intend	-0.062	0.082	0.452	-0.415	0.490	0.398
intl_sales	0.005	0.081	0.951	0.056	0.469	0.906
emp_startup	0.010***	0.003	0.006	0.090**	0.046	0.048
rd_intens	0.002*	0.001	0.065	0.016*	0.009	0.065
rd_never	-0.246*	0.132	0.064	-1.494**	0.647	0.021
rd_occasional	(omitted)			-0.243	0.477	0.611
rd_always	0.034	0.079	0.666	(omitted)		
_cons	44.975	187.075	0.81	420.719	1107.354	0.704
Obs			206	**Obs**		206
Prob > F			0.089	**Wald chi(2)**		28.93
R-squared			0.1232	**Prob>chi2**		0.3123
Root MSE			0.4277	**Log Psudo**		-99.2977
				Pseudo R2		0.1214

Table 6 Marginal effects probit model for survival for human capital variables [Source: ONS]

	dF/dx	Std Err	P >|z|
nbr_founders	0.024	0.034	0.491
exp_abr	-0.028	0.082	0.730
exp_intl_work	0.038	0.075	0.615
edu_abroad	0.100	0.075	0.246
skilled_staff_pct	0.001	0.001	0.303
short_marketing_97	-0.212**	0.090	0.015
short_marketing_03	0.049	0.079	0.551
short_sales_97	0.130	0.075	0.101
short_sales_03	-0.043	0.083	0.597
short_finance_97	0.034	0.073	0.643
short_finance_03	0.086	0.080	0.329
short_productivity_97	-0.078	0.078	0.303
short_productivity_03	-0.145	0.098	0.113
short_mgmt_97	0.029	0.078	0.712
short_mgmt_03	-0.160	0.109	0.115
short_rd_97	-0.024	0.074	0.745
short_rd_03	-0.006	0.074	0.937
founder_joint	0.011	0.070	0.874
exp_ent	-0.106	0.100	0.320
skilled_tech_staff	0.003	0.007	0.642
rd_employees	0.001	0.001	0.424
vc_97	-0.118	0.121	0.291
vc_03	0.007	0.112	0.952
angel_97	-0.212	0.157	0.137
angel_03	0.076	0.096	0.473
grant_97	0.012	0.079	0.876
grant_03	-0.007	0.077	0.928
Number of obs		266	
LR chi2(27)		34.11	
Prob > chi2		0.163	
Pseudo R2		0.1144	
Log likelihood		-131.97662	

Table 7 – Multinomial logit regression for long-run performance 1997-2010 [Source: ONS]

	Persistence			**Exit**			**Survival**		
	RRR	Std Err	P>z	RRR	Std Err	P>z	RRR	Std Err	P>z
nbr_founders	0.323***	0.071	0.000	1.200*	0.126	0.082	1.034	0.103	0.736
exp_abr	0.598	0.213	0.149	0.812	0.247	0.493	1.152	0.313	0.603
exp_intl_work	0.745	0.237	0.355	2.378***	0.636	0.001	1.803***	0.398	0.007
edu_abroad	0.101***	0.053	0.000	0.766	0.231	0.377	0.483***	0.132	0.008
skilled_staff_pct	0.988**	0.005	0.016	1.000	0.004	0.929	0.997	0.004	0.475
short_marketing_97	3.332***	1.138	0.000	1.311	0.401	0.376	1.273	0.361	0.394
short_marketing_03	0.785	0.272	0.486	1.355	0.402	0.306	0.840	0.230	0.525
short_sales_97	0.600	0.209	0.143	1.507	0.459	0.178	1.462	0.409	0.175
short_sales_03	1.265	0.395	0.451	0.953	0.251	0.856	1.050	0.243	0.833
short_finance_97	0.516**	0.157	0.030	0.769	0.184	0.272	1.106	0.235	0.635
short_ finance_03	0.693	0.246	0.302	0.508**	0.162	0.034	0.745	0.212	0.300
short_research_97	0.933	0.247	0.793	0.697	0.006	0.144	0.720	0.154	0.125
short_research_03	2.484***	0.694	0.001	1.722**	0.436	0.032	0.818	0.189	0.385
founder_joint	0.979	0.309	0.945	0.989	0.239	0.963	0.528***	0.113	0.003
exp_ent	1.004	0.459	0.994	0.207***	0.083	0.000	0.428**	0.149	0.015
emptec_sh	1.066	0.048	0.156	1.025	0.045	0.574	1.099**	0.043	0.015
empd_sh	1.037***	0.006	0.000	1.035***	0.005	0.000	1.024***	0.005	0.000
vc_97	8.332***	4.297	0.000	5.093***	2.260	0.000	1.383	0.612	0.464
vc_03	0.787	0.405	0.642	0.805	0.321	0.588	0.779	0.295	0.511
angel_97	0.086***	0.054	0.000	0.566	0.228	0.158	0.078***	0.033	0.000
angel_03	6.797***	3.593	0.000	1.764	0.757	0.185	3.073***	1.256	0.006
grant_97	0.465**	0.180	0.048	1.012	0.261	0.963	0.717	0.170	0.159
grant_03	1.514	0.498	0.207	0.836	0.247	0.544	1.098	0.276	0.709

Log likelihood	-1693.5071
Number of obs	1624
LR chi2(69)	639.79
Prob > chi2	0
Pseudo R2	0.1589

Table 8 – OLS regressions for sales and employment growth [Source: ONS]

	Employment 2003-2010				Sales 2003-2010		
	Coef.	**Rob. SE**	**P>t**		**Coef.**	**Rob. SE**	**P>t**
nbr_founders	-0.144**	0.118	0.025	**nbr_founders**	-0.081	0.067	0.231
vc_97	-0.677**	0.476	0.021	**vc_97**	-0.778**	0.393	0.049
vc_03	0.153	0.382	0.563	**vc_03**	-0.018	0.325	0.956
angel_97	-0.610**	0.412	0.047	**angel_97**	-0.666**	0.333	0.047
angel_03	0.238	0.434	0.275	**angel_03**	0.089	0.264	0.736
grant_97	-0.021	0.321	0.942	**grant_97**	0.054	0.230	0.813
grant_03	-0.157	0.302	0.429	**grant_03**	-0.162	0.246	0.512
prod_capgood	0.011	0.288	0.945	**prod_capgood**	0.119	0.200	0.553
prod_consumer	-0.252	0.457	0.445	**prod_consumer**	0.058	0.384	0.88
prod_component	0.342*	0.327	0.085	**prod_component**	0.218	0.225	0.334
tech_combine	-0.057	0.290	0.713	**tech_combine**	0.225	0.203	0.271
tech_external	0.460***	0.312	0.003	**tech_external**	0.676***	0.190	0.000
tech_internal	0.299	0.310	0.103	**tech_internal**	0.286	0.222	0.200
sector_software	0.001	0.372	0.996	**sector_software**	-0.021	0.292	0.941
sector_hardware	-0.04	0.444	0.898	**sector_hardware**	0.034	0.326	0.916
sector_eng	0.18	0.472	0.579	**sector_eng**	0.294	0.283	0.302
sector_lifesci				**sector_lifesci**	-0.04	0.403	0.922
ind_5	0.01	0.418	0.975	**ind_5**			
age10	19.409	113.565	0.743	**age10**	73.819	65.425	0.261
new_entr	0.085	0.446	0.789	**new_entr**	0.166	0.234	0.477
lnWindow	-0.143	0.163	0.133	**lnWindow**	-0.083	0.126	0.513
intl_intend	0.007	0.312	0.97	**intl_intend**	-0.149	0.248	0.548
intl_sales	-0.105	0.292	0.546	**intl_sales**	0.055	0.217	0.802
emp_startup	0.011	0.028	0.21	**emp_startup**	0.011	0.014	0.439
rd_intens	-0.001	0.006	0.762	**rd_intens**	0.001	0.005	0.765
rd_never				**rd_never**	-0.241	0.390	0.536
rd_occasional	-0.004	0.494	0.99	**rd_occasional**			
rd_always	0.486	0.493	0.117	**rd_always**	0.074	0.256	0.772
_cons	-146.738	858.381	0.743	**_cons**	-558.23	494.526	0.261
Obs			193	**Obs**			192
Prob>F			0.169	**Prob>F**			0.103
R-squared			0.182	**R-squared**			0.125

Table 9 OLS regressions for sales and growth with human capital variable [Source: ONS]

	Employment growth2003-2010			Sales growth 2003-2010		
	Coef.	Rob. Std. Err.	P>t	Coef.	Rob Std. Err.	P>t
nbr_founders	-0.077	0.078	0.322	-0.024	0.074	0.745
exp_abr	-0.034	0.196	0.864	-0.148	0.247	0.551
exp_intl_work	-0.067	0.195	0.733	-0.151	0.202	0.455
edu_abroad	-0.237	0.255	0.353	-0.219	0.276	0.428
skilled_staff_pct	0.001	0.003	0.800	0.000	0.003	0.945
short_marketing_97	-0.183	0.184	0.323	-0.116	0.204	0.570
short_marketing_03	0.216	0.249	0.385	0.080	0.214	0.710
short_sales_97	0.116	0.175	0.507	0.098	0.201	0.627
short_sales_03	-0.141	0.217	0.515	-0.106	0.216	0.623
short_finance_97	0.109	0.182	0.551	0.361*	0.190	0.059
short_short_finance_973	-0.141	0.273	0.607	-0.160	0.296	0.589
production_0	-0.267	0.182	0.145	-0.558**	0.235	0.018
production_t	-0.043	0.238	0.857	0.212	0.264	0.422
management_0	-0.042	0.196	0.832	0.078	0.224	0.727
management_t	-0.044	0.251	0.861	-0.180	0.236	0.446
short_research_97	-0.084	0.157	0.592	0.031	0.188	0.868
short_research_03	-0.205	0.184	0.268	-0.244	0.220	0.268
founder_joint	-0.200	0.163	0.221	-0.297	0.208	0.154
exp_ent	0.217	0.272	0.426	0.286	0.333	0.392
emptec_sh	0.024**	0.011	0.032	0.027**	0.014	0.048
empd_sh	-0.003	0.003	0.351	-0.001	0.003	0.884
vc_97	-0.269	0.228	0.240	-0.476	0.272	0.082
vc_03	-0.196	0.247	0.429	-0.163	0.318	0.609
angel_97	-0.265	0.235	0.260	-0.494	0.284	0.084
angel_03	0.343*	0.182	0.061	0.356	0.271	0.190
grant_97	0.097	0.202	0.631	0.101	0.153	0.508
grant_03	-0.186	0.192	0.335	-0.227	0.208	0.276
_cons	0.268	0.198	0.177	0.290	0.218	0.185
Observations		251			249	
Prob > F		0.2612			0.1181	
R-squared		0.1193			0.1228	
Root MSE		0.9869			1.1728	

Table 10 OLS for annual employment growth [Source: ONS]

	1997-2010			2003-2010		
	Coef.	**Rob. SE**	**P>t**	**Coef.**	**Rob. SE**	**P>t**
nbr_founders	0.038*	0.021	0.072	0.026	0.032	0.386
vc_97	-0.261***	0.097	0.007	-0.055	0.148	0.683
vc_03	0.248***	0.081	0.002	0.074	0.124	0.506
angel_97	-0.180*	0.094	0.054	-0.138	0.135	0.306
angel_03	0.132	0.103	0.201	0.16	0.146	0.303
grant_97	-0.448***	0.084	0.000	-0.467***	0.120	0.000
grant_03	0.048	0.070	0.490	0.119	0.105	0.203
prod_capgood	-0.252***	0.056	0.000	-0.330***	0.087	0.000
prod_consumer	-0.453***	0.085	0.000	-0.529***	0.128	0.000
prod_component	0.022	0.070	0.755	-0.115	0.106	0.238
tech_combine	0.045	0.057	0.426	0.028	0.085	0.720
tech_external	-0.141**	0.065	0.030	-0.159*	0.091	0.100
tech_internal	-0.165***	0.062	0.008	-0.13	0.092	0.132
sector_software	-0.346***	0.099	0.000	-0.330**	0.126	0.023
sector_hardware	-0.349***	0.109	0.001	-0.408***	0.149	0.010
sector_eng	-0.368***	0.113	0.001	-0.356**		0.031
sector_material	-0.578***	0.110	0.000	-0.771***	0.147	0.000
age10	-95.035***	21.861	0.000	-73.198**	33.736	0.014
new_entr	0.224**	0.097	0.021	0.205	0.153	0.104
lnWindow	-0.112***	0.033	0.001	-0.193***	0.050	0.000
intl_intend	0.083	0.067	0.214	0.107	0.099	0.254
intl_sales	0.340***	0.062	0.000	0.207**	0.092	0.018
emp_startup	0.031***	0.007	0.000	0.027***	0.009	0.007
rd_intens	0.008***	0.001	0.000	0.007***	0.002	0.000
rd_occasional	0.011	0.092	0.902	-0.131	0.132	0.329
rd_always	-0.011	0.093	0.903	-0.082	0.135	0.546
_cons	720.755	165.230	0.000	555.99	254.970	0.014
Observations			2961.000			1306.000
Prob > F			.			0.000
R-squared			0.075			0.085
Root MSE			1.407			1.311

Table 11 OLS for annual sales growth [Source: ONS]

	1997-2010			2003-2010		
.	Coef.	Rob. SE	P>t	Coef.	Rob. SE	P>t
nbr_founders	0.048**	0.024	0.049	0.075**	0.038	0.048
vc_97	-0.296***	0.108	0.006	-0.344**	0.174	0.049
vc_03	0.271**	0.106	0.011	0.368**	0.180	0.041
angel_97	-0.392***	0.110	0.000	-0.554***	0.170	0.001
angel_03	0.232**	0.115	0.043	0.149	0.170	0.379
grant_97	-0.762***	0.098	0.000	-0.788***	0.154	0.000
grant_03	0.093	0.086	0.281	0.069	0.135	0.608
prod_capgood	-0.127*	0.071	0.074	-0.074	0.113	0.512
prod_consumer	-0.382***	0.097	0.000	-0.361**	0.157	0.022
prod_component	0.129	0.082	0.118	0.224	0.130	0.084
tech_combine	0.195***	0.070	0.005	0.237**	0.108	0.029
tech_external	-0.087	0.076	0.252	0.073	0.113	0.517
tech_internal	-0.181**	0.074	0.014	-0.150	0.117	0.201
sector_software	0.275***	0.098	0.005	-0.544***	0.167	0.001
sector_hardware	0.189*	0.114	0.098	-0.438**	0.194	0.024
sector_eng	0.182	0.113	0.107	-0.422	0.180	0.019
ind_5	-0.688***	0.122	0.000	-0.645***	0.188	0.001
age10	-47.291*	25.137	0.060	-0.447	40.837	0.262
new_entr	0.366***	0.108	0.001	0.391**	0.173	0.024
lnWindow	-0.055	0.040	0.174	-0.036	0.063	0.574
intl_intend	0.095	0.083	0.250	0.033	0.132	0.800
intl_sales	0.456***	0.079	0.000	0.587***	0.127	0.000
emp_startup	0.037***	0.008	0.000	0.044***	0.010	0.000
rd_intens	0.010	0.002	0.000	0.011***	0.002	0.000
rd_never	0.149	0.111	0.180	-0.264	0.176	0.136
rd_always	-0.112	0.115	0.331	-0.453***	0.121	0.000
_cons	363.088	189.994	0.000	7.637	308.689	0.000
Observations			2960.000			1444.000
Prob > F			0.000			0.000
R-squared			0.080			0.086
Root MSE			1.674			1.847

Table 12 Quantile regressions for top quartile of growth [Source: ONS]

	Employment 2003-2010			Sales 2003-2010		
	Coef.	**Rob SE**	**P>z**	**Coef**	**Rob SE**	**P>z**
nbr_founders	0.151	-3.310	-0.804	-0.104*	0.054	0.055
vc_97	-2.391***	0.702	0.001	-0.462	0.299	0.124
vc_03	0.624	0.535	0.248	0.003	0.264	0.990
angel_97	-0.855	0.571	0.139	-0.298	0.254	0.243
angel_03	1.063	0.685	0.125	0.140	0.235	0.550
grant_97	0.439	0.484	0.368	-0.582***	0.186	0.002
grant_03	-1.186***	0.399	0.004	0.053	0.186	0.774
sector_software	-0.800	0.505	0.118	-0.381	0.228	0.097
sector_hardware	-0.103	0.613	0.867	-0.315	0.255	0.218
sector_eng	-0.544	0.606	0.373	-0.124	0.275	0.654
ind_5	-0.413	0.513	0.424	-0.207	0.247	0.402
age10	-2.840*	1.585	0.077	1.215**	0.592	0.042
new_entr	-1.195	0.622	0.059	0.545**	0.257	0.036
lnWindow	0.214	0.263	0.419	0.057	0.108	0.599
intl_intend	-0.214	0.400	0.594	-0.356*	0.195	0.069
intl_sales	0.708*	0.407	0.087	0.109	0.172	0.528
emp_startup	0.034	0.034	0.317	0.029***	0.008	0.001
empd_sh	0.002	0.007	0.812	0.000	0.004	0.907
rd_never	1.119	0.771	0.151	-0.571	0.289	0.049
rd_always	0.441	0.468	0.350	-0.088	0.182	0.629
_cons	12.575***	4.626	0.008	-2.803	1.713	0.104
Observations		89			89	
Pseudo R2		0.267			0.110	