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How do High-Growth Firms Grow? Evidence from Cambridge, UK

Vivian Mohr & Elizabeth Garnsey

No: 2011/04, August 2011

UNIVERSITY OF CAMBRIDGE

Centre for Technology Management Working Paper Series

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How do High-Growth Firms Grow? Evidence from Cambridge, UK

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I.S.B.N. 978-1-902546-85-8

Abstract

This study quantifies the incidence and influence of rapid growth among firms in a high technology milieu. We draw on evidence from a longitudinal database of technology firms in Cambridge UK. Resource configurations and the entrepreneurial matching of resources to opportunities are addressed, using Penrosian growth theory. We examine how certain knowledge-resources of start-ups are related to firms' subsequent growth. We examine various firm growth modes to track how they are associated with firm and regional growth.

1. Introduction

Newly emerging firms can act as carriers of innovations that stimulate new economic activity, re-allocating resources to more productive uses (Schumpeter, 1934; Rosenberg, 1982). The extent to which new firms achieve this potential depends on their ability to survive and grow large enough to have an impact (Penrose 1995). Several studies have attempted to identify the distinctive characteristics of these firms and their contribution to economic development (e.g. Bjuggren, Daunfeldt and Johansson, 2010; Parker, Van Witteloostuijn and Storey, 2010; Yudanov, 2010). However rapid growth is rare, and it is still a puzzle as to what stimulates such growth in a minority of firms. Moreover, rapid growth may overstretch the firm's resources and lead to setbacks (Garnsey and Heffernan 2004). More evidence is needed on the incidence and influences on rapid growth.

Young rapidly-growing firms tend to concentrate in certain localities and contribute to regional development (Frederick, 2004; Stam, 2005; St-Jean, 2007; Acs and Mueller, 2008; Mason *et al.*, 2009). Examining growing firms within a locality can contextualise the incidence and influences on rapid growth. In this paper we focus on high tech firms in a pioneering cluster, and ask how certain resource endowments of start up firms are related to their subsequent growth. We look for evidence on initial resource configurations and the matching of resources to opportunities that are associated with rapid firm growth. These were questions addressed by Penrose (1995), who provided a basis for theorizing the issue of firm growth, usually treated in a pragmatic manner in quantitative studies. We look into how young resource-constrained firms access resources through strategic alliances. These, together with acquisitions and revenues from exports, can be viewed as ways in which young firms match their resources to opportunities in order to create and capture value. We examine various growth modes to see how they are associated with firms' exploiting productive opportunities and achieving rapid growth, as conceptualised by Penrose.

Multi-level, longitudinal evidence on cohorts of growing firms is needed to address these issues (Acs and Mueller, 2008; Mason *et al.*, 2009). Such evidence is rare, even in advanced economies (Anyadike-Danes, 2009; Mason *et al.*, 2009; Henrekson and Johansson, 2010). Here, we contextualise the study of firm growth by using longitudinal evidence on entrepreneurs and over 3000 technology-based firms in the high-technology cluster around Cambridge, U.K. The Cambridge data enable us to relate evidence on different ways of building resources to growth patterns and trajectories.

The next section reviews prior contributions and definitions relating to high-growth firms. We then specify the definition of high-growth firms used here and develop propositions to guide our investigation. Section 3 describes the methodological approach of this study. The findings resulting from this approach are presented in sections 4 and 5. These findings are developed as recommendations in section 6.

2. Theoretical Issues

2.1. Aspects of New Firm Growth

The topic of firm growth has attracted scholarly interest since Gibrat's contribution in the 1930s, the importance of rapidly-growing young firms being highlighted by David Birch (Gibrat, 1934; Birch, 1979). Studies have since identified the prominence and economic contribution of rapidly growing firms across a variety of national contexts and industries (e.g. Birch, 1979; Kirchoff, 1994; Jovanovic, 1999; Autio *et al.*, 2000; Halabisky et al., 2006; Yudanov, 2010). More recently, several scholars have studied the contribution of these firms to the development and change of a particular locality (e.g. Frederick, 2004; Stam, 2005; Julien, 2007; Acs and Mueller, 2008; Mason and Brown, 2010).

Studies of rapidly-growing young firms conclude that high-growth firms make disproportionate contributions to job creation. However fine grained analysis explaining the incidence of and influences on rapid growth are rare, partly because empirical evidence on high-growth firms is sparse, especially for some countries (Henrekson and Johansson, 2010). "… evidence for the UK on high-growth firms is very limited [and][...] what is conspicuous in both the job creation and gazelles literature is the very limited contribution of UK studies" (Anyadike-Danes 2009, p. 8-9).

Evidence that rapidly-growing firms make a disproportionate contribution to the economy has led to increased interest in the characteristics and strategies of these firms (e.g. Cunneen and Meredith, 2007; Moreno and Casillas, 2007; Bjuggren, Daunfeldt and Johansson, 2010; Parker, Van Witteloostuijn and Storey, 2010). It is held that there are "systematic differences in the way entrepreneurs […] create gazelles (i.e. firms that grow fast early on)" (Cunneen and Meredith, 2007, p. 39). The importance of firms' undertaking strategic adjustments as they grow has been recognised (Parker, Van Witteloostuijn and Storey 2010). Thus high-growth firms appear to be distinctive both in their resource endowment and the manner in which these resources are deployed (Penrose, 1995).

Issues of resource-endowment and deployment are at the centre of Edith Penrose's *Theory of the Growth of the Firm* (1959). Unlike conventional economics of the firm, concerned with optimal firm size, price and output, Penrose conceptualised firms as dynamic, continually changing entities that are faced with strong growth incentives (Penrose, 1995). Penrose's conceptualisation can be seen as comprising two closely related elements: how a firm builds up resources and the dynamic process through which these resources are matched with productive opportunities.

Penrose drew her evidence from established firms, but her approach is revealing when applied to new firms (Garnsey, 1998; Druilhe and Garnsey, 2004).

2.2. Initial Resource Endowment

In another stream of resource-based theory of the firm (Pitelis, 2004), Barney argued that early access to valuable, rare, inimitable resources could provide firms with an early sustainable competitive advantage (Barney, 1991). In this vein, firm growth researchers have focused on the early experience of the firm (e.g. Kimberley, 1979; Eisenhardt and Schoonhoven, 1990; Siegel, Siegel and MacMillan, 1993; Bamford, Dean and McDougall, 2000; Geroski, Mata and Portugal, 2010). Scholars have referred to these circumstances as "founding conditions", and more specifically as the set of external (macroeconomic and competitive) and internal conditions that prevail at the time of the firm creation (Geroski, Mata and Portugal, 2010, p. 510). Bamford, Dean and McDougall (2000) observed a close but diminishing relation between founding conditions and growth potential, while Geroski, Mata and Portugal, showed that founding conditions can have a lasting impact on a firm's survival ability (2010). These findings are congruent with Storey's observation that unless firms achieve growth early on they are less likely to survive (1994). Both early growth and rapid growth can be investigated from our evidence. While it is intuitive that firms benefit from a munificent initial resource endowment, the question arises as to which endowments in particular are beneficial. Insights into these issues would aid entrepreneurs and business support agencies (Moreno and Casillas, 2007).

2.3. The Resource-Opportunity Matching Process

The second element of Penrose's conceptualisation is the dynamic process through which firms match their resources to "productive opportunities" in the market in order to grow. Penrose distinguished between two modes of growth: organic growth, or internal expansion of the firm's resource base and growth through acquisition, or merger with the resource base of another firm (1995). She was interested in the internal dynamics of building a resource base organically rather than in mergers between resource bases of different business entities.

Much subsequent research assumed that firm growth was simply about organic growth (McKelvie and Wiklund, 2010). There have been calls for more research on the different "modes" of firm growth (Davidsson, Achtenhagen and Naldi, 2006; McKelvie and Wiklund; 2010). Davidsson, Achtenhagen and Naldi note that:

> "[d]ifferent modes of growth are a clearly under-researched area in the small business literature. It is so underresearched, in fact, that studies which merely map out the phenomenon would have considerable value even if they say nothing about antecedents and effects" (2006, p. 389).

Efforts to address these issues has led to a more refined conceptualisation of how firms can achieve growth. For instance, McKelvie and Wiklund highlight the growing prominence of hybrid growth modes such as alliance networks, which do not fit the traditional distinction between organic and acquired growth (2010). Gaining resources from foreign markets is another mode of growth that may benefit firms with specialist offerings for which there is a limited domestic market (Rennie, 1993).

3. Methodology

3.1. Operationalising Theoretical Constructs

In this paper we apply Penrose's concept of the dynamic, continually changing nature of firm growth to new firms. Many of the issues raised by Penrose are not easy to quantify (Garnsey and Leung, 2008). However quantifiable issues also arise; these include the initial resource endowment of high-growth firms and the modes through which these firms achieve early expansion. Here we attempt to devise and apply metrics that are relevant to some of the issues outlined in the broader Penrosian conceptual approach to firm growth. Specifically, we study the role of certain initial resource endowments and map out the incidence of different growth modes. Table 1 summarises how such conceptual issues are operationalised to be amenable to quantitative evidence.

Concept	**Construct**	**Empirical Focus**	**Metrics**
Resource-Base Development	Initial Resource Endowment,	Venture Capital Investment	Investment ($m)
	Intergenerational Learning	Firms' knowledge-resources, based on participants' experience	Incidence of spin-off and serial enterprise
Resource-Opportunity Matching Process	Growth Mode	Alliance Patterns (resource access opportunities)	Incidence of alliance/acquisition/
		Acquisition Patterns (resource merger opportunities)	
		International operations	Revenue from overseas operations

Table 1 – Operationalisation of Study

Building on Penrose, we can relate growth modes to the resource base required to pursue different forms of growth. These in turn relate to the matching of resources with productive opportunities, opportunities offered by alliances, by acquisition and by foreign operations.

A methodological issue is that of success bias (Shane 2009, p. 147). To avoid success bias, we needed longitudinal data and evidence both on firms that achieve high growth (HGFs) but also those that do not (N-HGFs). We required evidence on firms that have initial endowments deemed to be favourable (IEFs) and those that lack these apparently favourable attributes (N-IEFs). In this paper, longitudinal data is analysed for 3 out of these 4 alternatives (table 2).

		Initial Resource Endowments (VC, serial entrepreneur, parent)	
		Favourable	*Unfavourable*
High-Growth Firms	*Yes*	Data Analysed	Data Analysed
	No	Requires Analysis	Data Analysed

Table 2 – Summary of Conditions and Growth Rates Analysed

The longitudinal relational database used here enables us to follow firms from start up, whether favourably endowed or not, through to their later experience, whether high-growth or not. A fourfold differentiation was also made for the analysis of mode of growth evidence. Figure 1 summarises the variables investigated to explain the incidence and influence of high growth firms in the population of firms we take as an exemplar. .

After an overview of the evidence, we go on to compare rapid growth firms with other firms. We raise two related issues: How likely are high-growth firms to exhibit certain attributes; and how

likely are firms with certain attributes to be high-growth firms (Table 2)? The first of these questions is explored in sections 5.2. and 5.3. where we also look at alliances and international operations, of particular importance in technology-intensive firms (Katila, Rosenberger and Eisenhardt, 2008; Ozcan and Eisenhardt, 2009). The likelihood that firms with favourable characteristics actually achieve high growth is examined through odds analysis in section 5.4. This is approach is further developed in the subsequent discussion. We begin with an overview of the database used.

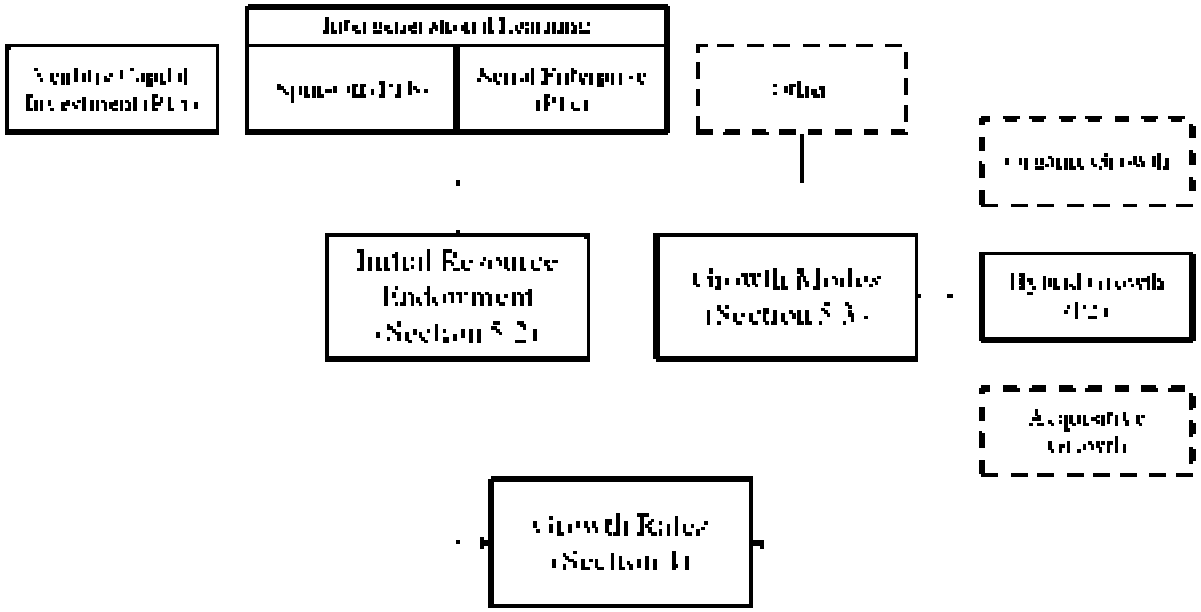


Figure 1 – Variables Analysed from the Conceptual Framework

3.2. Data Sources

The data for this study is derived from the Cambridge Technology Enterprise Dataset (CTED). This was developed as a 20-year collaboration between the University of Cambridge and the Cambridgeshire County Research Unit (CCRU)[1]. This has been extended by archival and media-sources, including over 183,000 press reports (see table 3). These sources provide rich evidence on 3099 technology companies from twelve sectors active in the Cambridge cluster between

1988 and 2008, covering all employment by technology-based firms in the area. The number of firms in the various fields of CTED depends on the availability of evidence for the relevant field-indicators in the data subsets (see table 3). Some of the evidence in the subsets is missing for the wider population of firms, but revealing and consistent evidence is available over the various fields and datasets.

Indicator	**Primary Source**	**Secondary Source**	**Size of Resulting Set**
Employment	CCRU	FAME, FACTIVA, Archives, Interviews	Database of 3099 companies
Subsets of the above comprehensive database of Cambridge high tech firms			
Financial Performance	FAME	FACTIVA, Archives	Dataset of 1336 companies
Venture Capital	VentureXpert	FACTIVA, Archives, Interviews	Dataset of 247 companies
Alliances	FACTIVA	Archives, Interviews	Dataset of 397 companies
Serial Enterprise	FACTIVA	FAME, Archives	Dataset of 92 companies

Table 3 – Sources of Evidence

Every population of firms is distinctive, but processes of growth have common features (Davidsson, 2005; Henrekson and Johansson, 2010; Stangler, 2010). This provides a rationale for choosing a local longitudinal database for analysis. The analysis is of interest for what it tells us about firms growing in a pioneering technology cluster, but also for identifying processes and modes of firm growth that occur not only in the Cambridge area but wherever firms grow.

3.3. Analytical Approach

Quantitative material was compiled in a relational database to ensure consistent analysis across different sources. Our preferred method was to work close to the data. We had already sorted the data to select high growth firms, making quartile regression based on rates of growth unsuitable. Instead we examined between-group differences in endowments and growth modes on the one hand and growth rates on the other. Finally we conducted odds analysis (section 4.4) to estimate the odds of growth being randomly associated with the factors in question.

The authoritative OCED definition of high-growth firms was selected (Ahmad and Gonnard, 2007; Moreno and Casillas, 2007; Daunfeldt, Elert and Johansson, 2010). High-growth firms were thus defined as

> "[a]ll enterprises with an average annualized growth greater than 20% per annum, over a three year period. […] Growth can be measured by the number of employees or by turnover. […] Ten employees in the beginning of the growth period is suggested as provisional size threshold." (Eurostat-OECD, 2007, p. 61).

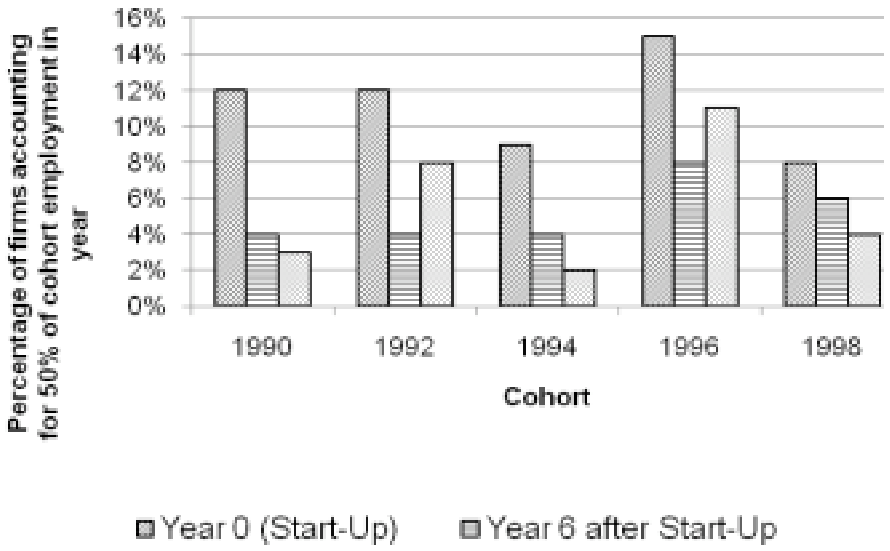
Gazelles were defined as those high-growth firms, which achieved these requirements within five years of firm creation. Qualitative material was initially coded openly, and subsequently categorised into emerging categories (Strauss and Corbin, 1990). A re-coding took place one month after the initial coding exercise to check the reliability of the categories. Independent coding was carried out by a collaborator to ensure consistency. We present the findings in the next section.

4. Evidence on Firm Growth Patterns in the Population of Firms

4.1. Early Growth

In this section we look at the incidence of rapid growth among the firms in the database, and the incidence of early growth among them. We examine the contribution of these firms to jobs in their cohort and to the population of firms.

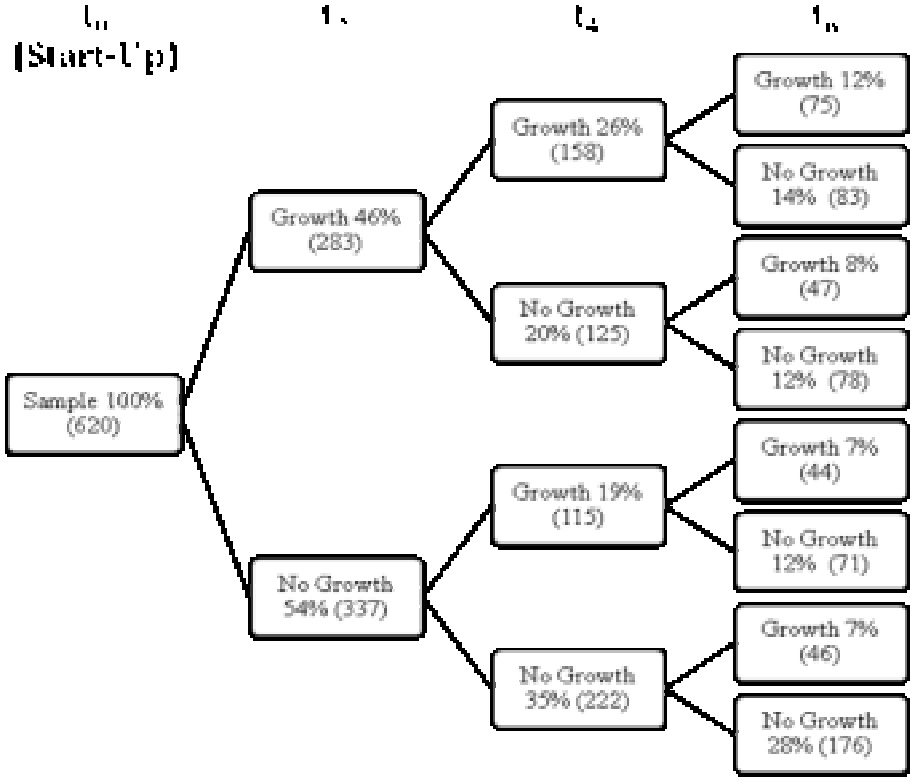
In the Cambridge area, technology firms pursuing early growth of any magnitude had a profound impact on employment in the cluster. Figure 2 tracks the companies accounting for around 50% of employment in their cohort six and ten years after (even year) formation. Congruent with the findings by Phillips and Kirchoff (1989) and Storey (1994), jobs in the cluster were concentrated in a small number of firms within that cohort. 91% of these firms had achieved growth of any magnitude within the first two years following the cohort entry date.



Source: CTED

Figure 2 – Percentage of Firms Accounting for 50% of Jobs in their Cohort of Firms 0-10 Years of start-up

Despite the long-term impact on jobs of early growth, the incidence of any growth among the population of firms was low and uneven. Growth in firms does not necessarily persist beyond the limited period chosen in definitions of high growth firms, and growth even for this period is limited to a small proportion of all firms. In figure 3, data for 620 firms from the 1990 to 2002 even-year cohorts has been combined to show how comparatively rare it is to see continuous employment growth of any kind. Only 12% of the wider sample firms achieved employment growth over the time period during which young high-growth firms, or "gazelles" achieve continuous rapid growth. Figure 3 points to the paradox that among those elite firms that achieved early growth over the specified period, 70% subsequently experienced growth reversal[2].



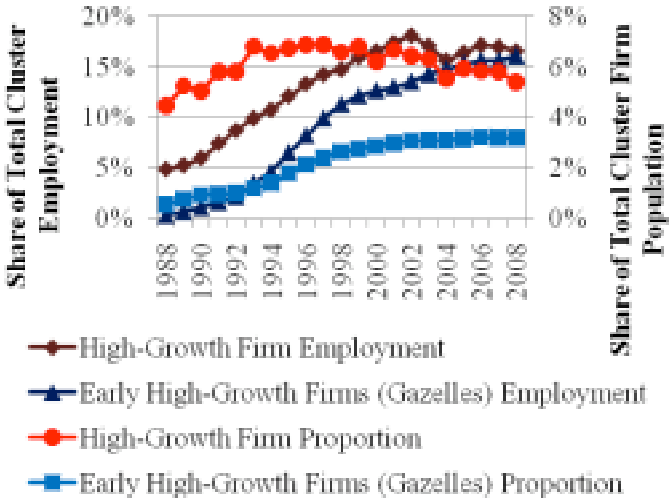
Source: CTED

Figure 3 – Proportion of All Even-Year 1992-2000

Firm Cohorts Experiencing Any Growth

4.2. Rapid Growth

The comparatively few firms that succeeded in sustaining early growth at a rapid pace (above 20% per year), made noteworthy and disproportional contributions to the total of tech jobs. Figure 4 illustrates the share of high-growth firms at large, and those high-growth firms that achieve continued rapid growth during at least three of the first five years after start-up ("gazelles"). *These two categories of firms account for nearly 30% of cluster employment, without ever accounting for more than 10% of the cluster's share of firms.* While early and rapid growth was found in a small proportion of the cluster's early population of firms, the incidence of both rose during the favourable economic conditions that prevailed after the slump of the early 1990s to the early 2000s. From the early 2000s onwards, the incidence of high-growth firms and gazelles continued to increase in Cambridge, but at a reduced rate. Nonetheless, early growth firms, although they accounted for only half of all *firms* that achieved high-growth, by 2008 accounted for almost as many *jobs* in the cluster as did all high growth firms. This shows the subsequent benefits of early growth and that early growth firms grew to be bigger than firms that grew later on in their trajectories.

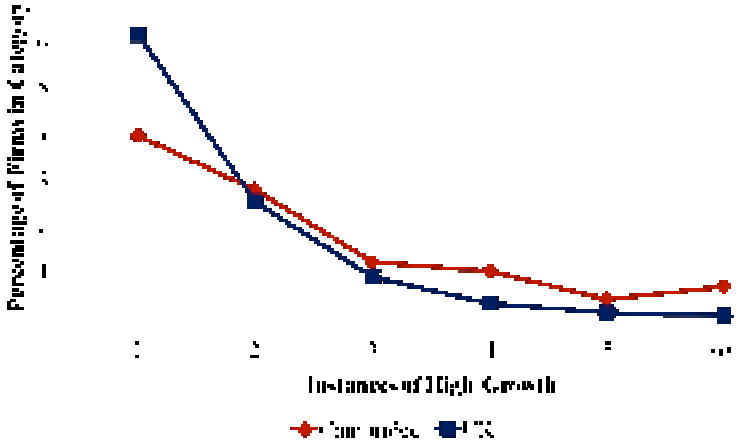


Source: CTED

Figure 4 – Share of High-Growth Firms and Early High-Growth Firms ("Gazelles") in Cluster Employment and Number of Firms

Figure 5 shows the percentage of Cambridge firms experiencing one or several instances of rapid growth (e.g. growth equal or exceeding 20% per annum). This analysis indicates that three or more instances of rapid growth occurred in just over 10% of firms.

National data are available to help identify distinctive features of the Cambridge tech database firms. A comparison with the national incidence of high growth firms (Anyadikes-Danes *et al.*, 2009) reveals that single instances of rapid growth in Cambridge high-tech firms are somewhat lower than in the national study for all types of firms. But repeated instances of rapid growth are more common among Cambridge tech companies (see figure 3). Given that the share of high-growth firms in Cambridge (~ 6%) is in line with the national average, Cambridge firms have been experiencing a trajectory of "step-wise" growth, with repeated periods of stability (or growth assimilation) following episodes of rapid growth, possibly because of strong business cycle effects (Drofiak and Garnsey, 2009).



Source: CTED

Figure 5 – Instances of High-Growth in Cambridge and the UK

Prior work has indicated that when rapid growth overstretches firms' capacities this leads to growth setbacks or interruptions. Our data provide rare evidence on firms' growth trajectories over time. The number of high-growth firms that did not experience growth interruption over several years is small. Table 4 illustrates three generic firm growth paths, this time mapping trajectories of rapid growth firms. Based on the methodology proposed by Garnsey and Heffernan (2005), inflection points in firms' growth paths were coded, with inflections identified as involving a 20% change in size. Even in the case of rapid growth firms, nearly half experienced growth reversal, somewhat below the proportion in the overall population of firms in the technology cluster. Thus rapid growth does not guarantee long term expansion.

Growth Trajectory	High Growth Firms	All Firms
 Continuous Growth	9%	3%
 Growth Setbacks Overcome	30%	17%
 Growth Setbacks not Overcome	47%	53%
Other	14%	27%

Source: CTED

Table 4 – Firm Growth Trajectories

We turn now to identifying factors associated with firm growth. This analysis is presented in the form of propositions about certain factors that are likely to be associated with growth. This analysis is selective since not all relevant factors can be analysed in a single paper.

5. Evidence on Factors Associated with Firm Growth

5.1. Propositions

5.1.1. Resource Base Development: Initial Resource Endowment

The first set of issues summarised in figure 1 relates to firm's initial founding conditions, which we investigate here with particular reference to initial resource endowments or "internal" founding conditions. As Shane among others has pointed out, favourable founding conditions can position firms for successful growth (Shane, 2009). Accordingly, we posit:

P1. HGFs have specific initial endowments beneficial to resource-building

The set of potentially relevant founding conditions is vast (Eisenhardt and Schoonhoven, 1990; Baum, Locke and Smith, 2001). For the purpose of this exploratory analysis, we focus on early access to funding, and intergenerational learning (Eisenhardt and Schoonhoven, 1990; Storey, 1994; Wright, 1998; Garnsey, 1998).

To support its early expansion, firms may seek to attract investment by venture capitalists (Wright, 1998; Gompers and Lerner, 2001). Venture capitalists offer firms early access to funding, in addition to advice and managerial talent. Research on venture capital shows that

firms with venture capital involvement pursue more aggressive growth targets – partly to fulfil the return requirements of venture capital investors (Wright, 1998). Issues of ownership of high-growth firms have attracted interest (Bjuggren, Daunfeldt and Johansson, 2010), with evidence in Davilla, Foster and Gupta (among other studies) showing that venture capital involvement may benefit firm growth (2003). Accordingly, we posit:

P1a. HGFs are more likely to have received venture capital investment.

A third aspect potentially influencing firm's founding conditions are intergenerational effects. These effects relate to the notion of a stock of previously accumulated knowledge on the creation and management of new firms and the risks associated with the development of products and technologies, which can be accessed on a personal level through serial entrepreneurs or, on the firm level, through corporate or academic spin-off firms (Garnsey and Heffernan, 2005; Mason and Harrison, 2006; Garnsey, Ferriani and Lorenzoni, 2009). Corporate spin-offs can occur as a result of employee dissatisfaction, e.g. in the aftermath of a merger (Klepper, 2007). Also, a firm's technology programmes may develop in such a way, that a firm's management determines that this technology should be further explored and potentially exploited in a separate enterprise (Chesbrough, 2003; Garnsey, Ferriani and Lorenzoni, 2009). A striking example of this "speciation" process is provided by Garsey, Ferriani and Lorenzoni, (2009). Academic spin-offs from a research institution may constitute an attempt by researchers to commercialise their technology (Garnsey, 1992; Shane, 2004). Recent findings relating to this phenomenon are summarised by Djokovic and Souitaris (2008).

There has been disagreement regarding the role of intergenerational effects in the growth of new firms. One stream of work has argued that access to this stock of knowledge reduces the survival

risk and initial learning requirement of new firms, thereby enabling them to deploy their resources towards their growth objectives. Regarding serial entrepreneurship, this stream of work has argued that serial entrepreneurs can help strengthen a firm's managerial abilities – a key determinant of a firm's ability to grow in Penrose's conceptualisation of the firm (Penrose, 1995; Westhead *et al.*, 2005; Garnsey and Heffernan, 2005; Mason and Harrison, 2006). Specifically, this stream of work suggests that the involvement of serial entrepreneurs, who were able to develop their managerial abilities during prior undertakings, would provide firms with early access to this key resource. Indicatively, Mason and Harrison's (2006) insightful account of entrepreneurial recycling illustrates the potential relevance of serial entrepreneurship, while Mason and Brown emphasise the importance of serial entrepreneurs for high-growth firms (2010). Similarly, Zhang (2011) suggests that serial entrepreneurs are able to raise more outside investment for their venture, while Gompers *et al*. (2010) found that entrepreneurs with a track record for success are more likely to succeed in subsequent ventures. Equally, this stream of work suggests that firms that were established as part of a spin-off from another enterprise or a research institution can also draw on a stock of prior knowledge, and, possibly, an established resource base, as well as technologies that had previously been developed and "incubated" in the "mother" enterprise or institution (Shane, 2004; Clarysse *et al.*, 2005; Klepper, 2007; Djokovic and Souitaris, 2008; Garnsey, Ferriani and Lorenzoni, 2009). This stream of work suggests that such pre-incubation or pre-established resource base may improve a firm's ability to grow.

In contrast, another stream of work has questioned the intergenerational effects. Regarding serial entrepreneurs, work in this stream suggests that suggested that the performance of entrepreneurs is solely resulting from luck (Kihlstrom and Laffont, 1979). Moreover, university have been advised to be wary of spin-off activities by their members because so many spin-off firms are not commercially oriented (Lambert Report, 2003). In this context, Harrison and Leitch's analysis of

Northern Irish academic spin-off companies found that many spin-off firms "are technology lifestyle businesses not dynamic high-growth potential start-ups" (2010, p. 1241). In view of the latter, this inquiry therefore investigates:

P1b. High-growth firms are less likely to have been established by a serial entrepreneur.

P1c. High-growth firms are less likely to have been established as a spin-off.

5.1.2. The Resource-Opportunity Matching Process: Modes of Firm Growth

As illustrated in figure 1, the second set of issues relates to growth modes. Underlying this is the notion that more extensive use of hybrid growth modes would enable firms to leverage their productive base better, to exploit opportunities and potentially broaden their set of opportunities for growth (McKelvie and Wiklund, 2010; Penrose, 1995; Garnsey, 1998).

This study limits its focus to two exemplars of hybrid modes of growth: strategic alliances and international operations. As McKelvie and Wiklund noted, non-organic firm growth can be distinguished into acquisition and a great variety of "hybrid" growth modes, which range from licensing over alliances to spin-offs (2010). While other studies have already shown the prevalence of acquisitive growth among high-growth firms, evidence on the use of hybrid growth modes is more limited (Pasanen, 2007; McKelvie and Wiklund, 2010; Mohr and Garnsey, 2010). The strategic alliance literature has argued that strategic alliances can provide firms with growth opportunities (DeMeyer, 1999; Katila, Rosenberger and Eisenhardt, 2008; Ozcan and Eisenhardt, 2009). Alliances give resource-constrained young firm access to the resource base of other players to help them exploit new opportunities. Thus:

Proposition 2a. HGFs make more intensive use of alliances than non-HGFs.

Proposition 2b. HGFs make earlier use of alliances than non-HGFs.

Firms can choose to align with larger corporations or smaller peer companies, each of which can have different implications for the firm (Garnsey and Leung 2008; Katila, Rosenberger and Eisenhardt, 2008). Accordingly, it may be the case that:

P2c. HGFs pursue an alliance pattern different from that of non-HGFs.

"The issue of alliances leads us to networks and […] to growth through internationalization" (Davidsson, Achtenhagen and Naldi, 2006, p. 377). There is a rich literature on the internationalisation of high-technology firms (Burgel, Fier, Licht and Murray, 2001; Licht, Murray and Woywode, 2008; Coeurduroy and Murray, 2008). This shows that firms seeking to commercialise advanced products may find local demand insufficient to sustain the company (McDougall et al., 1994; Rialp-Crado et al., 2002). Such firms may seek to expand their operations in wider geographical markets (Ansoff, 1965). To investigate this issue we propose to see if P2d holds for our evidence:

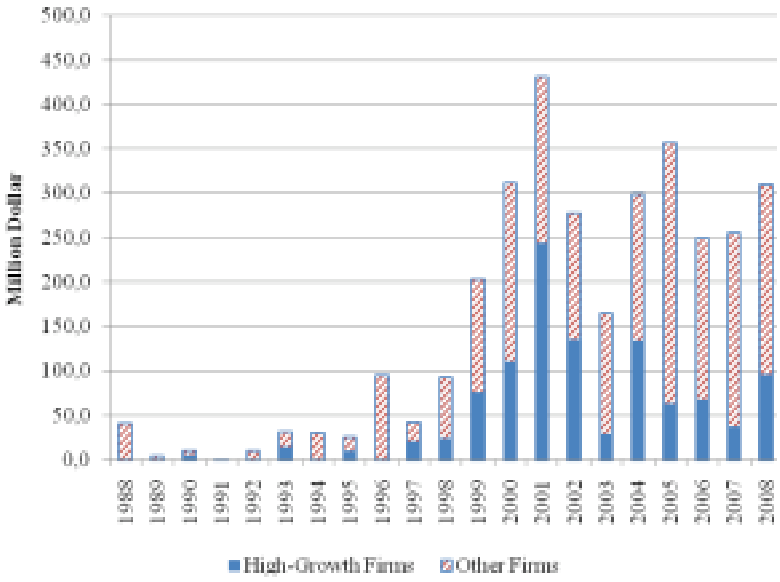
P2d. HGFs obtained a greater share of their revenues from overseas than non-HGFs.

5.2 .Findings on Initial Resource Endowment and Growth Rates

5.2.1. Venture Capital

A key consideration for firm growth is the early resourcing of firms. Figure 4 describes the investment patterns for venture capital – a key funding source for technology-based firms – in the Cambridge cluster. As was the case with /alliances, venture capital investment reached a peak during the technology bubble and subsequently established itself at higher levels than during the pre-bubble period.

Figure 6 also shows that high-growth firms received substantial support from venture capital investors. A quarter of all venture capital was invested in high-growth firms. Although no less than _ of VC was allocated to firms that failed to grow rapidly, rapid growth firms were four times more likely to attract VC than other firms. Overall, 35% of high-growth firms received venture funding, compared to 8% of all firms[3]. Venture capital investors seek an early harvest, achieved in a few cases. Among acquired firms that attracted VC, 17 high-growth firms achieved sales prices nine times higher than their total VC investment. Firms attracting VC are more likely to grow (proposition 1a) though this may be because VCs invest in the most promising firms, those more likely to have grown even without their input.

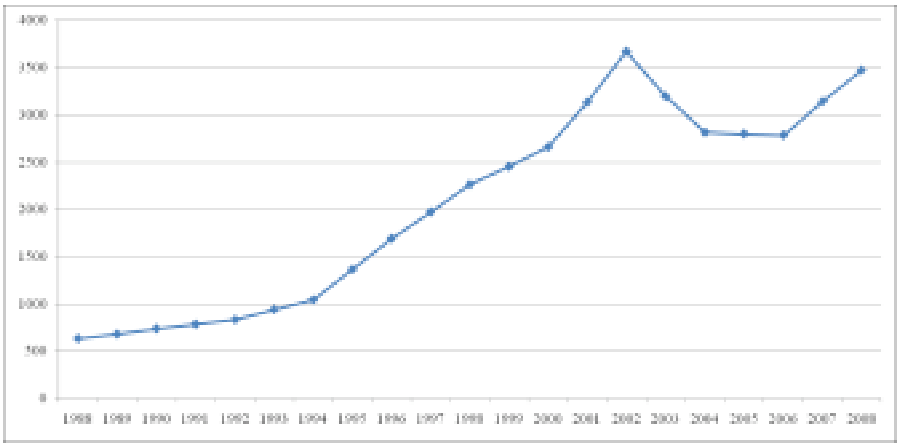


Source: CTED

Figure 6 – Venture Capital Investment in Cambridge 1988-2008

5.2.2. Intergenerational Learning

Some entrepreneurs and managers are well placed to benefit from prior experience through firm spin-off or serial entrepreneurship. Figure 7 summarises evidence on firms established by serial entrepreneurs – here defined as individuals who founded at least 3 firms.

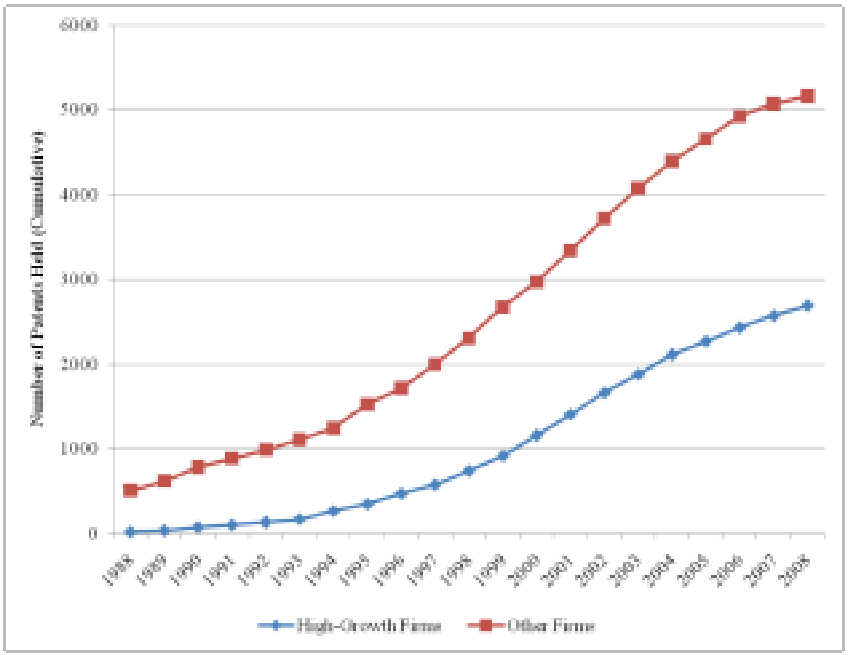


Source: CTED

Figure 7 – Employment in Cambridge Tech Firms founded by Serial Entrepreneurs

The proportion of high growth firms founded by serial entrepreneurs (12%) was four times higher than that of all tech firms in the cluster founded by serial entrepreneurs (3%). This does not support proposition 1b: high-growth firms were more likely than other firms to have been founded by serial entrepreneurs, even though this was relatively rare overall.

Another intergenerational effect – spin-off activity – was also prominent among high-growth firms. Whereas on 11% of all firms in the cluster were either academic or corporate spin-offs, this was nearly three times as common for high-growth firms, among which 31% of firms had been founded as spin-offs. Accordingly, proposition 1c is not supported: among high growth firms there are a higher proportion of firms started as spin-offs than among other firms. This may also partially explain the disproportionate share of high-growth firms in patenting activity as new patentable technologies more commonly developed in university labs than by SMEs. In 2008 high-growth firms accounted for more than one third of all cumulative patents held by Cambridge high-technology firms (figure 8).



Source: CTED

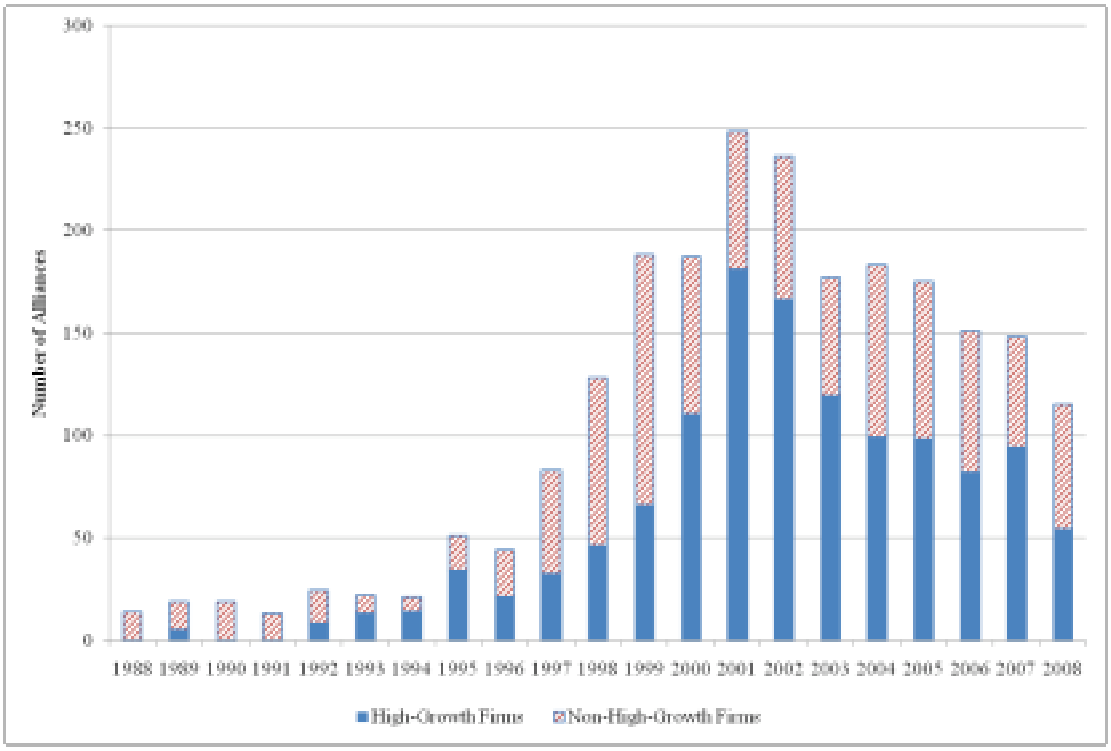
Figure 8 – Cumulative Patents Held by High-Growth and Other Firms 1988-2008

These two findings suggest that Cambridge high-growth firms benefitted from intergenerational effects, an observation in line with the findings by Garnsey and Heffernan (2005) and Garnsey, Ferriani and Lorenzoni (2010).

5.3. Modes of Firm Growth and Growth Rates

5.3.1. Alliances

Alliances enable firms to access and make use of resources from another firm to complement their own resource base. Figure 9 shows a peak of alliance activity among Cambridge high tech firms during the dot-com bubble, after which alliance activity declined though remaining at higher levels than during the pre-peak period.



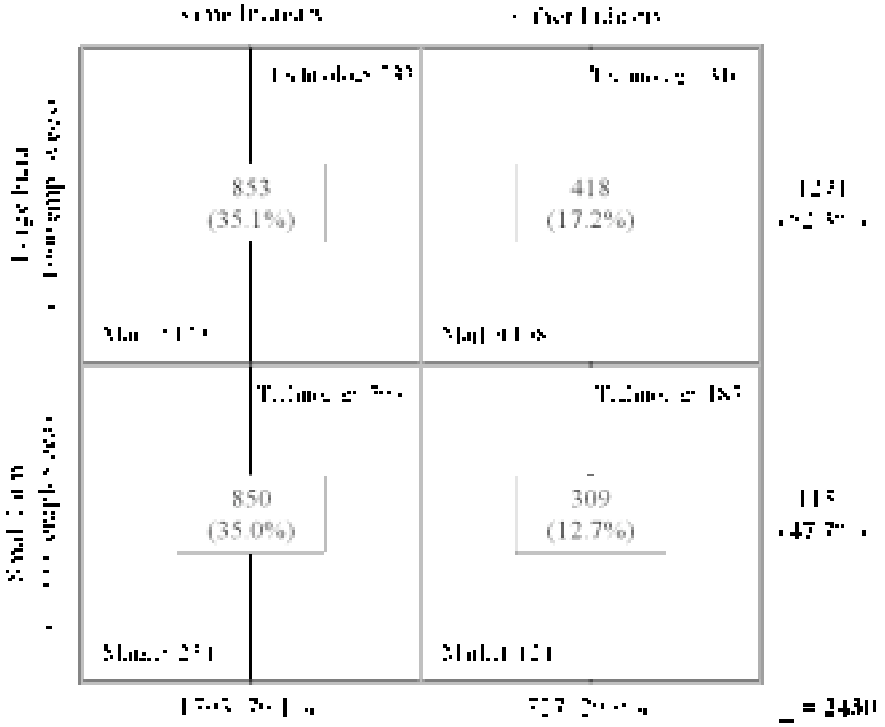
Source: CTED

Figure 9 – Reported Alliance Activity among Cambridge Firms

Alliances are commonly reported among the whole population of Cambridge tech firms. High growth firms report somewhat more alliances (on average 7.7 alliances compared with 6.4 alliances by other firms; medians of 5 for high-growth firms compared to median of 2 by other firms). But a small set of firms, whose business model is based on partnership activities, contribute significantly to the overall alliance figures, with the ten most active firms accounting for forty percent of all alliances. On average, high-growth firms report their first alliance after 6 years, while other firms report their first alliance after 7 years. While hypotheses 1a and 1b are thus supported by the evidence, further research on this matter is needed.

What kinds of alliance are undertaken by Cambridge tech firms? For this purpose, we analysed the content of reported alliance agreements of Cambridge technology firms. In total, 2430

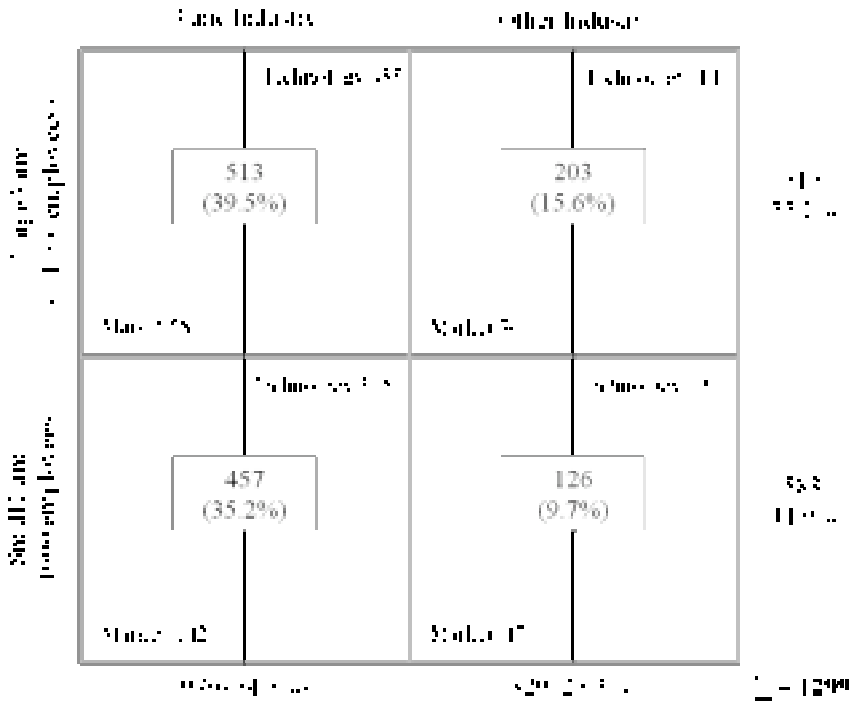
alliance agreements were reported for these firms[4]. Figure 10 shows the size and industry alignment of the alliance partner, and whether the alliance had a focus on a firm's commercial or technological capabilities. Cambridge firms tend to focus on technology-related alliances, predominantly with firms in their sector. In contrast, differences between the sizes of partner firms are less pronounced, although firms appear to favour larger partners in alliances with partners outside a firm's own sector.



Source: CTED

Figure 10 – Typology of Alliances by Cambridge Firms

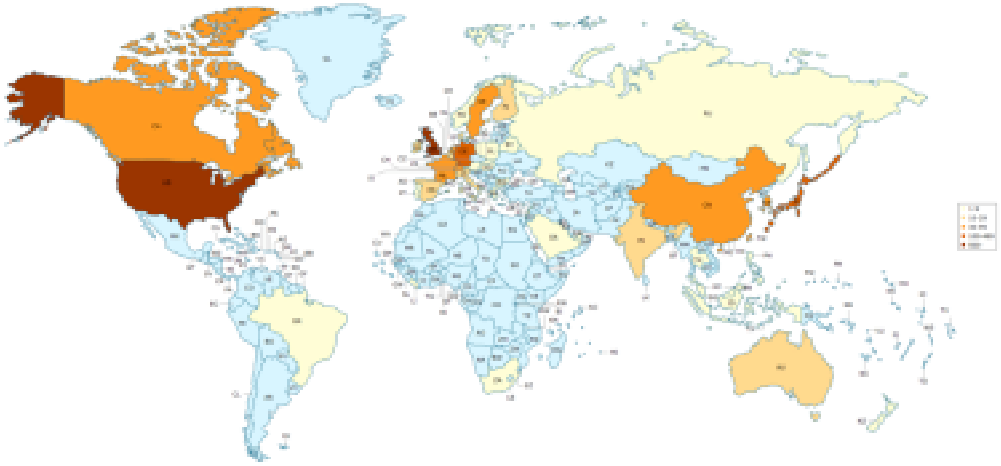
Figure 11 focuses on the alliance agreements concluded by high-growth firms. The chi-squared confirms that the pattern for high-growth firms differs from that of the overall population ($p < 0.01$).



Source: CTED

Figure 11 – Typology of Alliances by Cambridge High-Growth Firms

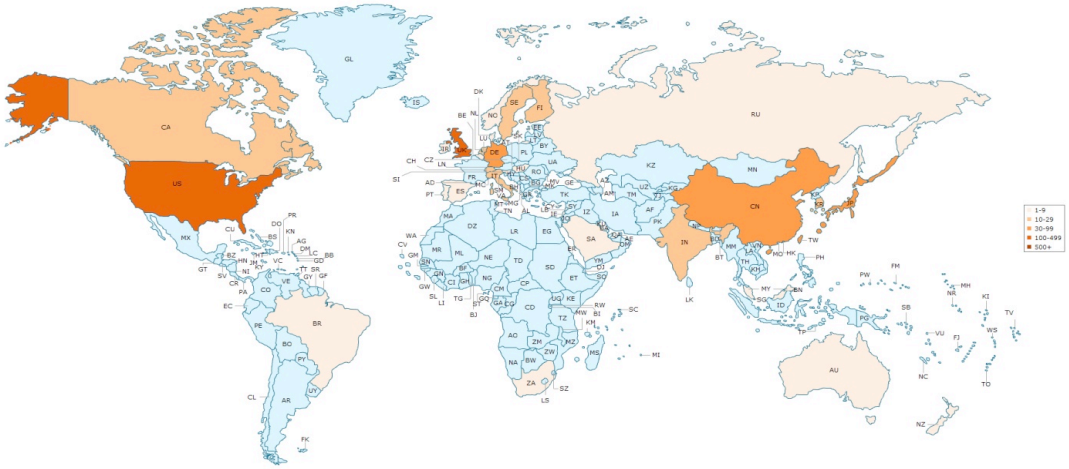
It is also possible to identify the location of alliance partners. Figure 12 illustrates the geographic distribution of alliance partners. Cambridge firms partner mostly with American and other British companies. However, strong alliance ties can also be observed with the German, Japanese, Taiwanese and Chinese markets.



Source: CTED

Figure 12 – Location of Alliance Partners

Figure 13 provides a similar analysis for the alliance partners of high-growth firms. High-growth firms partnering more often with American, Taiwanese and Dutch firms than do other firms. The evidence supports proposition 1c that high-growth firms pursue a different alliance strategy, even though the geographic, size and sector patterns for both groups of firms appear to be largely similar.

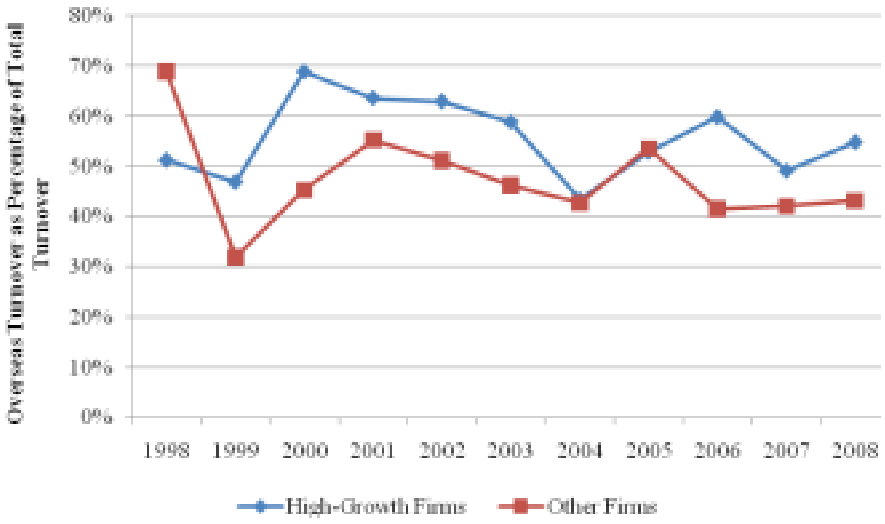


Source: CTED

Figure 13 – Location of Alliance Partners of High-Growth Firms

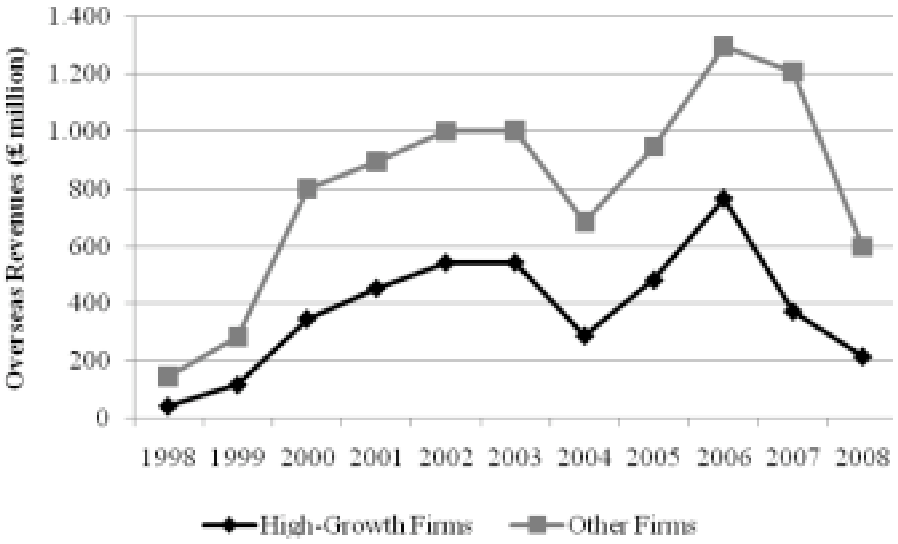
5.3.2. International Orientation and Firm Growth Rates

Overseas alliance partners are one indicator of a firm's international orientation. An additional indicator is the amount of revenues generates from overseas operations. A greater share of overseas revenues relative to total revenue indicates a stronger international orientation. Figures 14 and 15 compares the share of overseas revenues in total revenues for local Cambridge high-growth firms and local Cambridge cluster firms at large. High-growth firms exhibit more revenues from overseas than other firms. Thus, proposition 1d (high-growth firms are more internationally oriented than other firms in the cluster) is supported.



Source: CTED

Figure 14 – Share of Overseas Turnover in Total Turnover of Cambridge Tech Firms



Source: CTED

Figure 15 – Overseas Turnover by Cambridge Technology Firms

5.4. Variance Analysis

To estimate the odds of firms with certain attributes achieving high growth we created a logit model to study the association between key variables summarised in figure 1 and discussed in the foregoing analysis. The model is set out as:

$$p(HGF = 1) = f(\__1 VENCAP + \__2 SERENT + \__3 SPNOFF + \__4 ALLIES + \__5 INTREV) + \_$$

The dependent variable HGF is a binary variable that takes the value 1 if the firm experienced rapid growth and 0 if not. The OECD definition of rapid growth is used (enterprises with an average annualized growth over 20% p.a. over a three year period and a minimum of ten employees). The dependent variable is described by a series of independent dummy variables and a constant _. VENCAP takes the value 1 if the firm had received venture capital investment and 0 if not. SERENT takes the value 1 if the firm has been established by a serial entrepreneur and 0 otherwise. SPNOFF takes the value 1 if the firm has been established as a spin-off

company and 0 otherwise. ALLIES takes the value 1 if the firm had concluded alliance agreements and 0 otherwise. INTREV takes the value 1 if the firm had reported international revenues and 0 otherwise. Estimation results are summarised in table 5. Overall model fit was good ($p < 0.01$) and further analysis yielded no indication of multicollinearity problems.

Variable **Constant**	**Incidence** **Frequency**	**Odds Ratio**[4]	_	_	**p**
VENCAP	248	2.7	0.0797	0.2708	***
SERENT	92	1.1	0.2097	0.1697	-
SPNOFF	396	1.7	0.1278	0.3338	**
ALLIES	396	2.2	0.1281	0.3342	***
INTREV	280	4.5	0.0904	0.2867	***

Note: ***, ** and * denote statistical differences at the 1%, 5% and 10% significance level

Table 5 – Odds Ratio of Firm Growth on Basis of Specified Attributes

Table 5 shows the relative odds[5] for the different factors associated with firm growth; the best chance of high growth is that for firms with international operations, confirming that growth firms need customers and benefit from exporting to international markets. This is a robust measure, indicating that the odds of rapid growth are four times higher for firms that have international revenues than for those with serial entrepreneurs. Venture capital is an input indicator twice as strong as serial enterprise or spin-out in improving odds of high growth, but as we have seen VCs may select firms with other favourable attributes. Alliances, an indicator of growth-mode, come just behind venture capital in the extent to which it affects the odds of achieving high growth, but is only half as likely to be found with high growth as are international operations. It would be expected that these attributes favour growth above all when found

together, through growth-reinforcement effects, but the co-variances are not as high as might have been expected (table 6). In interpreting these odds ratios it is important to note the relative differences in incidence of the various factor associated with growth. A high odds for a rare attribute such as serial enterprise may represent effects that operate differently from those that are more commonly found.

Co-variances					
	VENCAP	SERENT	SPNOFF	ALLIES	INTREV
VENCAP	1.0000				
SERENT	0.0138	1.0000			
SPNOFF	0.0363	0.0159	1.0000		
ALLIES	0.0369	0.0159	0.0404	1.0000	
INTREV	0.0183	0.0067	0.0159	0.0236	1.0000
Correlations					
	VENCAP	SERENT	SPNOFF	ALLIES	INTREV
VENCAP	1.0000				
SERENT	0.2295	1.0000			
SPNOFF	0.4013	0.2804	1.0000		
ALLIES	0.4077	0.2800	0.3623	1.0000	
INTREV	0.2356	0.1372	0.1659	0.2463	1.0000
Correlation Coefficients					
	0.9981	0.1093	0.5090	0.7759	1.4966

Table 6 – Summary of Logit Model Co-variances and Correlation Coefficients

6. Summary and Concluding Remarks

This study has examined attributes of high growth firms in the wider context of the population of tech firms in a high tech cluster. The study investigated two closely related issues: the likelihood that high-growth firms exhibit certain characteristics, and the likelihood that firms exhibiting

those characteristics are high-growth firms. Table 7 summarises the congruence between propositions and available evidence.

Proposition 1 is that high-growth firms benefit from munificent initial resource endowment, analysed here as access to venture capital and intergenerational learning through spin-off or serial entrepreneurs. This is supported by evidence from the Cambridge cluster. This suggests that high-growth firms build on founding conditions more munificent than those of other firms. The founding conditions of many Cambridge high-growth firms reveal the advantages enjoyed when proven entrepreneurs commercialise technology that was pre-developed in a corporate or academic research setting and gain the support of venture capital investors, in conditions of international demand for the firm's technology-based product. But while half the group of high-growth firms experienced this self-reinforcing cycle of advantages, the other half achieved the tight rope act of several periods of rapid growth without these benefits. The longitudinal database allows of future analysis of any firms that enjoyed beneficial starting conditions but did not experience subsequent growth, for which there was not scope in this paper (Table 2).

In contrast, support for proposition 2, that high-growth firms make distinctive use of hybrid growth modes is more limited. While the evidence indicates slightly earlier and more intensive use of international operations and alliances by high-growth firms, the majority of tech based firms in the cluster engaged in alliances, showing how difficult it is for such firms to rely solely on their own resources. Further enquiry may reveal important differences in the way non-organic growth modes are used by different types of firms. What is striking is that just ten high growth firms contributed 40% of all alliances in the cluster.

Item	Proposition	Findings
Early endowments and growth rates		
1a	HGFs are more likely to have received venture capital investment	+
1b	HGFs are less likely to have been established by a serial entrepreneur.	-
1c	HGFs are less likely to have been established as a spin-off.	-
Mode of growth and growth rates		
2a	HGFs make more intensive use of alliances than non-HGFs.	(+)
2b	HGFs make earlier use of alliances than non-HGFs.	(+)
2c	HGFs pursue a different alliance pattern than non-HGFs.	(+)
2d	HGFs obtained a greater share of their revenues from overseas than non-HGFs.	+

Table 7 – Summary of Findings

Apart from these empirically-based contributions, the investigation leading to these findings summarised here illustrates the importance of longitudinal database evidence. As shown by Baldwin, longitudinal database evidence, still rare outside Canada and Scandinavia, has the potential to support real advances in analysis (Baldwin and Gu, 2004; Baldwin, 1995, 2005) and to provide empirical grounding for policy recommendations.

For Cambridge tech-based firms, several factors identifiable ex-ante were associated with high-growth. While this does not constitute causation, the evidence points to policy measures that could support firms in developing their initial resource-base. Support to firms in specialist sales and marketing - to help them reach international markets for specialist output - is likely to be the

most useful form of business support for such firms. Much can be done to help clusters of firms in specific specialist area to get to know foreign markets, a very costly undertaking for small start ups but for which there are economies of scale if done collectively. The emphasis is on specialist knowledge, since sales and marketing requirements are highly sector and technology-specific. Workshops and specialist subscriber websites would be of interest to most specialist firms with advanced technologies, and would not provide zero-sum support to competing firms as tech firms tend to have idiosyncratic rather than competing products.

Intergenerational learning is a feature of cluster benefits (Mason and Harrison 2006). Network events to encourage connections may be supplemented by commercial training for SMEs and workshops for larger firms in implementing an "open innovation" approach (Chesbrough, 2003)[6]. Specialist support to exporting firms requires specialist knowledge. Quality data gathering could underpin support to innovative firms that are contributing to the trade balance and gaining experience in emerging technologies and markets.

We have seen that rapid growth is rare. While we have identified factors which improve the odds of growth, it is noteworthy that the overwhelming majority of firms, including fast growth firms, encounter growth setbacks. Rapid growth itself may overstretch the firm's resources and so give rise to setbacks. These create disincentives limiting the number of firms that aim for growth. However early rapid growth carries sufficient advantages to override such considerations. More detailed evidence is needed to help firms to anticipate and allow for and overcome the difficulties associated with rapid expansion, especially into international markets.

Appendix A – Entry Timing

As noted in the review of prior work, founding conditions can be both internal and external. The foregoing analysis focused specifically on internal founding conditions, or initial resource endowment, in line with the broader Penrosian conceptual model. Firms' choice of growth modes may partly be the result of the initial resource base that firms are able to assemble, and the environment within which firms start up. An initial criterion is the evolution of a firm's immediate local environment at the time of the firm's entry. Early entrants into a cluster may benefit from easier access to physical infrastructure, yet may find it more difficult to attract outside talent (Garnsey and Lawton-Smith, 1998; Druilhe and Garnsey, 2000). Later entrants may be able to benefit from knowledge spillovers and a more established labour market yet may face increased competition for staff, space and funding from other firms in their locality (Feldman, 1994, 1999; Audretsch and Stephan, 1996; Audretsch and Feldman, 1996). The ability to access certain resources may thus partially depend on the entry timing of a firm.

Figure 16 provides an entry analysis for firms in four sectors for which such analysis was possible[7]. While the entry patterns of high-growth firms differs across the different industries, it is evident that high-growth firms were mostly among the early entrants or early majority of firms entering into the Cambridge cluster. For illustrative purposes, windows during which 50% of entry during the 1988-2008 time period occurred are outlined with solid (all firms) and dashed (high-growth firms) borders. Again, the 50%-entry-window for high-growth firms tends to occur before that of all firms. Accordingly, 2a that high-growth firms tend to be early entrants into a cluster is supported. In an innovative milieu it can be inferred that early entrants enjoy benefits of early technology market entry, or at least avoid late entry difficulties.

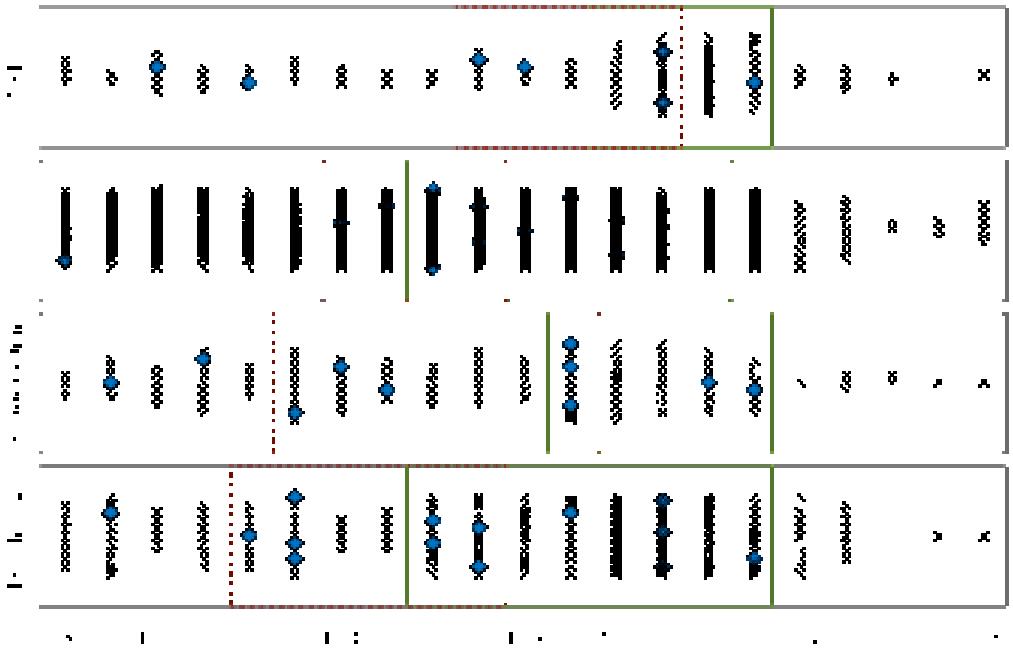


Figure 16 – Entry Patterns in Selected Technology Sector, 1988-2008[7]

Footnotes

[1] Research institutes and retail outlets have been removed from the IfM database of Cambridge area tech based firms.

[2]It would be of interest to follow the firms that achieved growth in periods t4 and t6 after failing to grow earlier on (a total of 22%); the issue of growth continuity has been neglected in prior research and requires separate study.

[3] Among those 8% of all high-tech firms in Cambridge receiving VC, about the same proportion (27%), received VC in their first year of operation as high-growth firms (30%).

[4] This figure includes only "local" firms, i.e. companies who had initially been established in Cambridge. This criterion was introduced to avoid distortions through alliances concluded by large multinationals attracted to the cluster.

[5] The odds ratio is the ratio of the odds of an event occurring in under one set of conditions as opposed to the odds of it occurring under another set. The term is also used to refer to sample-based estimates of this ratio. The odds ratio can also be defined in terms of the joint probability distribution of two binary variables, but this requires random variables.

[6] These recommendations are congruent with Shane's recommendation for a more selective approach to supporting entrepreneurship (2009).

[7] Crosses indicated individual firms founded in the respective year, squares indicate high-growth firms founded in the respective year. Solid frame indicates 50% entry window for all firms, dashed frame indicates 50% entry window for high-growth firms.

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