Institute for Manufacturing

Centre for Technology Management

Exploring the Constituents of Growth in a Technology Cluster: Evidence from Cambridge, UK

Vivian Mohr & Elizabeth Garnsey

No: 2010/01, September 2010

UNIVERSITY OF CAMBRIDGE

Centre for Technology Management Working Paper Series

These papers are produced by the Institute for Manufacturing, at the University of Cambridge Engineering Department. They are circulated for discussion purposes only and should not be quoted without the author's permission. Your comments and suggestions are welcome and should be directed to the first named author.

Exploring the Constituents of Growth in a

Technology Cluster: Evidence from Cambridge, UK

Vivian Mohr & Elizabeth Garnsey

No: 2010/01, September 2010

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

Abstract

High-growth firms appear to be key drivers of new industries and technologies. Here we investigate the contribution of these and other types of firm to a technology cluster, in the context of 'creative destruction' shaping the evolution of the cluster. Evidence on the reallocation of scarce resources through processes of creative destruction is scarce. But in a cluster the effects of creative destruction can be traced through such developments as (1) firm exits and entries (2) change in firm size distribution and (3) acquisition of firms. We apply churn analysis, firm size transition analysis and analysis of acquisition to the technology cluster in Cambridge UK over twenty years. Firm growth contributed two-thirds of all new job creation, while entry-exit turbulence accounted for one third of job creation. High-growth firms accounted for a quarter of jobs created in the Cambridge cluster during this period, without ever making up more than 3% of all tech firms. There has been an increase in average firm size and profitability. A fall in entry rates and fewer firms moving up into larger size categories in recent years point to adverse conditions for innovative new firms even before the financial crash.

Executive Summary

Research on high-growth firms has yielded important insights, but questions remain. In this study, we address questions on the contribution of specific groups of firms to a spatial collectivity or cluster of firms, with particular reference to high growth firms. Our evidence is drawn from a pioneering European high-technology cluster, Cambridge, UK. Schumpeter argued that creative destruction is an enabler of innovation, re-allocating productive resources to more efficient use. Here we examine how the emergence and expansion of the Cambridge technology cluster was shaped by creative destruction as evidenced by turbulence in firm entries, exits, by firm size transitions and by bursts of acquisition. We examine both rates of growth and modes of growth. These methods could be used elsewhere to yield comparative evidence; here we attempt only a brief comparison with Silicon Valley before and after the technology crash, yielding evidence on the resilience of the Cambridge cluster on the eve of the financial crisis.

We give particular attention to the contribution to the cluster of high growth firms - these "gazelles", have been viewed as vehicles for future economic growth in advanced economies. The European Union's Lisbon Strategy emphasised the development of clusters and support for rapidly growing firms, while the United Kingdom's industrial policy has viewed growth firms as being at the heart of new industries and new jobs. Economic downturn raises questions as to ability of such growth firms to persist and flourish. The dynamics of high growth firms and trends shaping the clusters to which they contribute require longitudinal evidence, which is scarce internationally but available on Cambridge for 1988-2008.

Our evidence shows that the Cambridge tech cluster grew because it generated new firms, because its constituent firms grew and because the cluster attracted firms from elsewhere. Between 1988 and 2008, employment in the Cambridge tech cluster grew from under 27,000 to over 43,000 jobs, with the IT sector providing about half of all firms but important sectors also in biopharm, telecoms and instrumentation among others. Numbers of tech based firms increased from around 800 in 1988 to around 1300 in 2008 (depending on definitions used) as a series of entry waves occurred. Growth of indigenous firms contributed two-thirds of all new job creation 1988-2008, while entry-exit accounted for one third of job creation. High growth firms accounted for more than 16% of total employment and almost a quarter of net new job creation during growth years although they never made up more than 3% of all tech based firms. High growth firms contributed disproportionately to cluster employment during periods of upswing but were also important in maintaining growth during periods when the cluster at large contracted. Since 2004, tech firms having fewer than 10 employees have accounted for a smaller proportion of the total, following the formation and collapse of a micro-firm bubble, particularly in IT. This trend reflects the technology crash of 2000-2001 in the US, where many customer firms are located. In Cambridgeshire there was a fall in numbers of IT start ups and IT firms with fewer than 5 employees after 2002. Over the period as a whole, the proportion of small firms declined in relation to midsized and larger firms, but small firms remained the most numerous category, a feature of firm size distribution which is also found nationally and internationally. Patenting activity declined by more than half following the technology crash; the recent retreat of venture capital may have decreased incentives for patenting.

Larger firms showed less volatile growth than smaller ones. Four of the most successful firms, for example, ARM, Autonomy, Domino and CSR, have grown throughout the period, setting up

international operations. The creative destruction thesis would interpret the sustained growth of a minority of firms as evidence that resources and talents were redirected from some less successful firms to those performing well enough to expand. While this interpretation is in question without more detailed evidence on resource mobility, undoubtedly the ability of firms to overcome growth setbacks and sustain their growth after an interruption was critical for the cluster. The increasing number of larger firms, in particular the growth of the 'big four', reduced the vulnerability of jobs in the cluster to the downturn.

Acquisition is another dimension of turbulence affecting entry and exit. In the Cambridge cluster, acquisition activity intensified from the mid-1990s onwards, with foreign firms constituting almost half the acquirers. While evidence on the impact of acquisitions is very limited because of reporting discontinuities, corporate acquirers generally attempt to introduce more professional management systems and operations. This should enable the acquired unit to grow more profitable with fewer inputs of employees and other assets. Our evidence is consistent with such developments. However there may also be an element of destruction in the turbulence of acquisition. High performing firms were particularly likely to be acquired (the probability was three times higher than for other firms), and in many cases our data show that acquisition was followed by job losses, asset reduction and repatriation of profits by foreign owners. However firms performing well were also ten times more likely to grow through acquisition than those with less rapid pre-acquisition growth. In contrast with independent US companies such as Microsoft, Oracle and Google, where founder managers continued to drive strategy, innovation in high performing Cambridge firms may have been affected by strategy being driven from corporate HQs. Post acquisition spinoff effects require further investigation. A positive effect of such spinoffs is the new entry effect, as those selling their firms to acquirers start out new firms, so increasing the pool of firms eligible for growth into larger categories. Historical evidence shows that it takes many such start ups to generate a firm able to sustain high performance.

The data presented in this study are from the eve of the financial crisis, for benchmarking with further survey details when these become available. We have built on a subset of the county employers' database (1988-2008) of the employment records of all technology firms in the Cambridge area. We have added fields on acquisitions, spin-offs and patents and performance data mainly from Companies House. We selected 2329 firms in six sectors for investigation. For most years, we had data on firms providing over 70% of employment by technology-based firms in the area. While interpretation of these figures cannot be generalised to the population of firms as a whole, it reveals trends for the firms concerned, which make up about two thirds of current tech based firms in the area.

Schumpeter recognised that small firms were highly vulnerable, and only a few of them grow in such a way as to displace established rivals. But a simple form of the creative destruction thesis (small firms grow to displace incumbents) cannot convey responses to business cycles in clusters. Average tech firm size in Cambridgeshire has increased since the downturn. In the short term and during a downturn, fewer microfirms imply fewer firms vulnerable to recession. Just as in the plant world, new shoots are 'switched off" under adverse environmental conditions, so a reduction in the proportion of very small and vulnerable firms in the cluster may reflect an adaptation to a difficult economic environment. The larger firms providing more local jobs in uncertain times may reduce the incentive to potential entrepreneurs to start new firms. In the longer term, there may be compensating effects at work if those fewer firms that are started

during a recession prove to be unusually robust. We have shown elsewhere that there were very high survival rates among the cohort firms founded in the recession of the early 1990s; low entry rates can be compensated for when economic conditions improve. However a prolonged recession may prevent such recovery.

Firm entry figures show that as less favourable conditions followed the technology boom period, there was a reduction in start up rates. We have also identified a lagged effect whereby a reduction in the pool of smaller firms was followed in the next survey period by a reduction in the number of midsized companies. For the most successful Cambridge tech firms, the period when they were mid-sized was formative. A reduction in the mid sized category implies a reduction in the pool eligible to move into larger size categories. Thus without policy input to loosen constraints on young knowledge based firms, business cycles effects on the cluster may persist over time. If these firms are to sustain their contribution to innovation and exports in a knowledge-based economy, considerable effort should be devoted to pilot policies to provide conditions favourable for their growth.

1. Introduction

Research on high-growth firms has been burgeoning and has yielded important insights into their nature and impact (Storey, 1994; Acs et al., 2008; Henrekson and Johansson, 2009). But unanswered questions persist. Here we address questions on the contribution of specific groups of firms to a spatial collectivity or cluster of firms, in the context of a pioneering European high-technology cluster, Cambridge, UK. We attempt a dynamic analysis, tracing the way in which the emergence and expansion of the Cambridge technology cluster was shaped by firm entries, exits, by firm size transitions and by acquisition trends; we examine both rate of growth and mode of growth (McKelvie and Wiklund, 2010). These methods could be used elsewhere to yield comparative evidence.

Academics and policy makers increasingly regard high-growth firms, often termed "gazelles", as vehicles for future economic growth in advanced economies. The European Union's Lisbon Strategy emphasised the development of clusters and support for rapidly growing firms – a position echoed by the United Kingdom's emerging industrial policy, which sees growth firms at the heart of new industries and new jobs (EU, 2004; BERR, 2009; BIS, 2010). If clusters of fast growth firms are so important, it is critical to understand their dynamics and that of the clusters to which they contribute.

We proceeded as follows. In section 2, building on a review of prior research, we develop propositions to guide our analysis. We explain our logic of inquiry and sources of evidence in section 3. Section 4 presents evidence from a variety of sources on the role of high-growth firms in the emergence of the Cambridge cluster. Finally, section 5 interprets this evidence in the light of our propositions and links the findings to prior research.

2. Theoretical Development

2.1. Prior Work

The development and growth of tech clusters reflect complementary effects: local firm formation, local firm growth and firm growth through acquisition or merger (Garnsey and Heffernan 2005). Over time, local effects attract entry of firms from elsewhere. Building on prior work we address the question: what is the contribution to the development of a technology-based cluster of growth by various types of constituent firms? We investigate this question in terms of a set of related propositions below. Our methodologies are designed to tap into processes of change over time, not to identify significance levels for cross-sectional findings of variance (Van de Venn, 2002).

While Gibrat provides an early example of firm growth studies, the origins of research on high-growth firms are commonly attributed to Birch (Gibrat, 1931; Birch 1979). Birch stressed the contribution of small firms to national employment in the United States, particularly that of rapidly growing firms termed "gazelles" (Birch 1979, 1981). Recent work has proceeded at three levels. The economic contribution of high-growth firms has been studied at a national level in a variety of contexts and economic systems. Jovanovic showed that in 1999 four U.S. high-growth firms had achieved valuations equal to 13% of the U.S. GDP (2001). At the meso-level, scholars have concentrated on high-growth firms within particular industries. Storey provides one instance of such work (1994). Recent work at this level has stressed the importance of high-growth firms' environment on their innovative capabilities (Sarkar et al., 2006; Acs and Mueller, 2008). This stream of work has begun to analyse the spatial distribution and impact of high-growth firms, analysing questions such as the role of high-growth firms in regional restructuring (Frederick, 2004; Stam, 2005, 2009; Julien, 2007). Research has highlighted the need for further analysis of this issue (Acs and Mueller, 2008). At the micro-level, researchers have sought to

develop concepts and identify distinguishing characteristics of high-growth firms for improved empirical testing and theorising. Moreno and Casillas develop a conceptual framework of high-growth firm processes (2005). Recently, this stream of work has developed an interest in the dynamics of high-growth firms, focusing on questions such as the strategic rationale underlying different growth patterns (e.g. St-Jean, Julien and Audet, 2008; Parker, van Witteloostuijn and Storey, forthcoming 2010). St-Jean et al. provide exploratory evidence on these issues (2008). All three approaches share the use of average growth rates as key analytic measures, while micro-level studies make use of case evidence. Storey provided an extensive review of early research (Storey, 1994), while Henrekson and Johansson offer a comprehensive survey of recent contributions (Henrekson and Johansson, 2009). They mention new entry and exit, organic growth and growth by acquisition as relevant themes. We explore all three, taking the technology cluster in Cambridge UK as an exemplar of a locality with a high concentration of innovative firms, presumably subject to forces of creative destruction.

In many prior studies cross-sectional methods predominate (Storey, 1994; Henrekson and Johansson, 2009). These approaches have provided insight but do not represent firm growth as a process unfolding over time (Garnsey 1998). Although some studies on high-growth firms provide evidence on firm age and survival, discussions of the processes underlying these indicators are limited. Accordingly, methodological approaches are needed that improve our understanding of growth processes over time. Elsewhere we look into the sustainability of growth by young firms (Garnsey and Mohr, forthcoming 2010). Our objective in this paper is the more limited one of using available data to trace the contribution over time of specific categories of firms, notably fast growth firms, to the Cambridge technology cluster.

2.2. The Investigation

While the impact of high-growth firms has been investigated at the national and industry level, there has been less research at the local level based on longitudinal evidence. Concentrations of high-growth firms, prominent in certain places can play a critical role in the development of local economies (Frederick, 2004; Julian, 2007). We investigate the proposition that:

> *P1: High growth firms contribute disproportionately to employment growth in a cluster.*

To assess the contribution of high-growth firms to cluster development, we explore three themes in particular: (1) entry/exit (churn rates), (2) growth of existing firms and (3) acquisition. Churn rates (also termed turbulence) provide evidence on Schumpeter's thesis that innovative new firms arise and replace old ones. Turbulence as a form of creative destruction was highlighted by Henrekson and Johansson:

> "a prerequisite for the growth of these [fast growth] firms is also that the process of creative destruction functions so that efficient new and expanding firms can attract resources from inefficient firms, resources that are released through contraction and exits. Without this dynamic reallocation the growth of firms will be hampered […]" (2009 p. 17).

It is a challenge to inform the creative destruction concept with relevant evidence; how can it be shown that attracted resources were released through contraction and exits of inefficient firms, rather than being derived from other sources, e.g. entry into an industry of firms also active in other sectors? But while entry and exit is not a zero-sum process, we can assume that in a small area there are constraints on the supply of skilled local labour for innovative firms and competition to attract investors. Thus the inference can be drawn that the entry and expansion of certain categories of new firms will, at least in part, be at the expense of the elimination of certain other local categories. The effects should show up in changes in creation of new firms

(net entries). Growth of incumbent innovative firms would exhibit the creative rather than destructive aspects of the process. Tech firms in Cambridge are mainly innovative and provide us with evidence for investigating our second proposition:

> *P2: The employment contribution to the cluster of net firm entry-exit is greater than the contribution to the cluster of growth by existing firms*

Detailed entry/exit and size category evidence is needed to support this inference about churn rates (relevant to Schumpeter's thesis on creative destruction) and to illuminate the broader question of the role of net new entries in the development of a cluster, relative to continuing growth of existing firms.

A second source of growth is the process of organic growth in firms located in a cluster (Arthur, 1989). Processes of this kind are difficult to quantify at the collective level of the cluster (Van de Ven, 2002). However, an indicator of growth processes as revealed by collective evidence is provided by numbers of firms moving from one size category to another (Birch, 1979; Biga, 2008). New firms predominate in smaller size categories. Because of the immature resource base of new firms and limited reserves of small firms, these categories are particularly likely to exhibit growth volatility (Garnsey, 1998). Accordingly, we investigate the proposition:

> *P3: Small firms exhibit greater growth volatility than large firms during the expansion of a cluster*

The third growth source highlighted by Henrekson and Johansson in the context of high-growth firms is that of growth achieved through acquisition of the resource base of other firms (2009; Pasanen, 2007). Accordingly, we propose:

> *P4: High-growth firms were more active acquirers than other firms.*

At the same time, however, growing and rapidly growing firms may attract corporate acquirers who eliminate the venture as an independent entity. Acquiring firms may seek to own the resource-base supporting the performance of high-growth firms, in an effort to overcome the problems of inertia and reduced innovativeness associated with large size (Dougherty and Heller, 1994; Ranft and Lord, 2002). High-growth tech firms may be particularly attractive targets for incumbents. There is a choice to be made between acquisition and independent growth for young firms that have achieved strong performance (e.g. Graebner and Eisenhardt, 2004; Casson, 2009). Owners of high growth firms may prefer to see the firm acquired, assuring returns to owners, rather than undergo the further risks of independent growth. Moreover acquirers are more likely to seek targets with a track record of strong growth. Accordingly, we propose:

> *P5: High-growth firms were more frequently acquired than other firms.*

At the regional level, as at the firm level, the impact of acquisitions on cluster development remains in question, though there have been an increasing incidence of "technology acquisitions" of this kind since the 1990s (Chaudhuri and Tabrizi, 1999; Gerpott, 2009). Work by Mason suggests that acquisition may support local economic activity by inducing business angels (private investors) to support start-ups (2004). On the other hand, acquisitions may impair a cluster's development when, following an acquisition, innovative entrepreneurs are replaced by corporate managers and when technologies and employment are transferred to less innovative owner companies, head quartered elsewhere. We begin with evidence on employment growth following takeover, investigating the proposition:

> *P6: Acquisitions resulted in job-losses in acquired firms.*

Later we look at other ways of measuring turbulence following acquisition.

These six propositions together depict links between high-firm growth and cluster development. Relationships between constructs outlined above are summarised in figure 1.

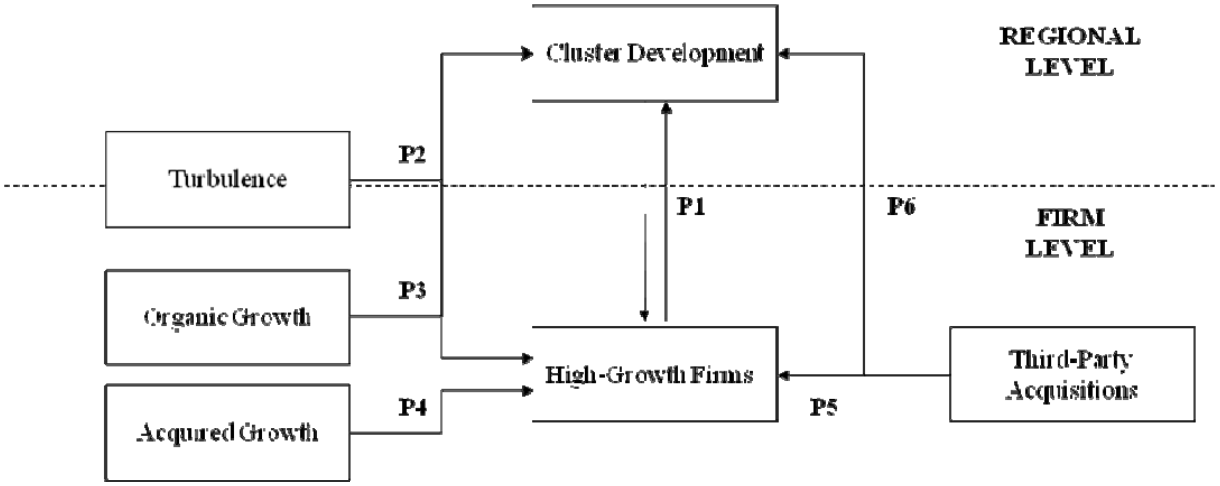

Figure 1 – Summary of Investigation

2.3. The Context

To operationalise relevant research questions we have asked them of a well-known cluster of technology-based firms – those in and around Cambridge, U.K. The Cambridge cluster emerged in the 1970s, unexpected and unplanned, in a famous university and market town (current population 150,000). The entrepreneurial processes unfolding in the Cambridge area were largely free of the effects of large government or corporate investment characteristic of other clusters. Around Cambridge University, productive opportunities emerged for entrepreneurs to meet growing international demand for specialist knowledge. Spin-off ventures originating from the university set off further cycles of attraction for businesses to move into the area (Garnsey and Heffernan, 2005; Drofiak and Garnsey 2009). We sought to uncover the dynamics of growth among different categories of firms which together resulted in the collective trends of cluster development and provide some indication of trends to come.

3. Methodology

3.1. Data Source

Our data are mainly from the IfM database on technology firms in the Cambridge area. This is the outcome of first author collaboration with Cambridgeshire County Research Unit (CCRU) over twenty years. We have built on a subset of their company commercial dataset (1988-2008) of the employment records of all technology firms in the Cambridge area (Garnsey and Heffernan 2005). We selected 2329 firms in six sectors for investigation. For most years, we had data on firms providing over 70% of employment by technology-based firms in the area. As the county database was limited to employment, we created a further dataset from public domain sources (the Mohr-Garnsey technology firm data set) with fields on acquisitions, spin-offs and patents and performance data. The wider performance data in the Mohr-Garnsey data set covered firms distributed (in terms of size and sector) somewhat differently from those of the overall population of technology-based firms in Cambridgeshire (CCRU/IfM). Thus interpretation of these figures cannot be generalised to the population of firms as a whole but reveals trends for the firms concerned, which make up about two thirds of current tech based firms in the area.

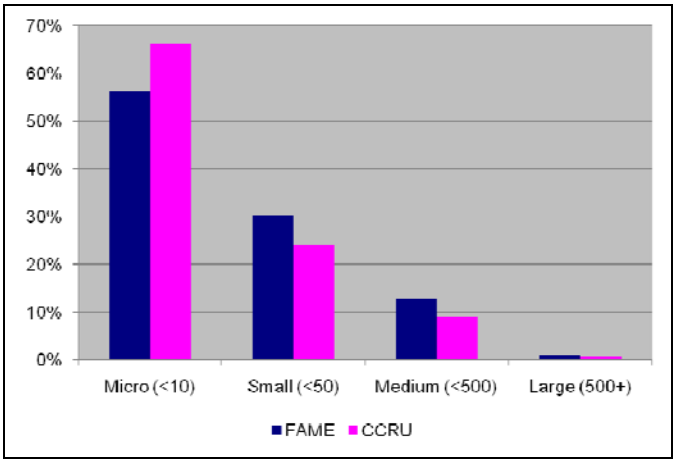

Figure 2 – Firm Size Distribution Comparison by Data Source

3.2. Analytic Approach

Our aim is to uncover processes of change over time (Van de Ven et al 2002). Accordingly we do not use cross sectional analysis, although cross sectional regression analysis is the standard methodology in many studies of firm growth. We used entry-exit analysis (churn analysis) over this period of time to operationalise ideas conveyed by the Schumpeterian term 'creative destruction', the idea that innovative new firms replace those that are eliminated by the forces of change. Churn analysis is used to examine the effects of new firms and exits of technology firms from the area, either through closure or departure. A second tool we use to capture change over time is firm size transition analysis. By this method we identified the net number of firms moving between each size category over each two year period, a negative value indicating a net flow of firms downsizing – thus moving to a smaller size category. Thirdly we examined entry of firms into the cluster through acquisition and the contribution of takeovers to growth of the cluster.

4. Evidence from the Cambridge Cluster

4.1. Firm Growth in the Cambridge Cluster: The Overall Scene

As we have seen, the Cambridge high tech phenomenon emerged in the 1970s (Segal, Quince and Partners, 1985). The number of technology-based jobs increased throughout the 1980s and 1990s, after a brief downturn in the early 1990s (figure 3). Firm numbers fell following the technology crash of the new millennium, but total jobs recovered during the boom period of 2006-8, despite a difficult period for technology firms worldwide.

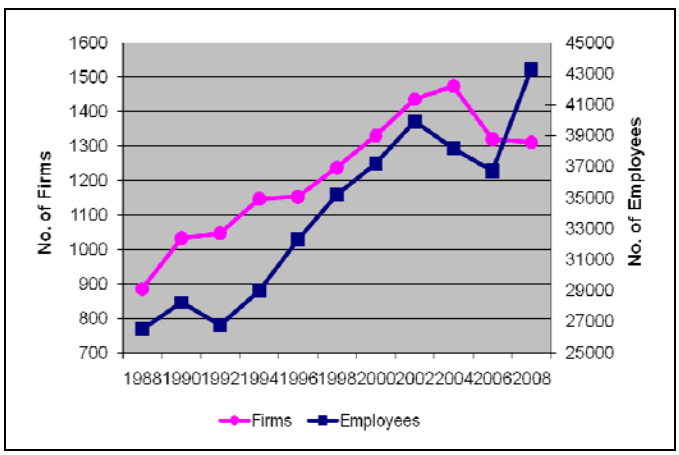

Figure 3 – Number of Firms and Employment in the Cambridge Cluster

The development of the cluster was shaped by waves of entry of firms into various sectors. Figure 4 summarises these waves, indicating the time periods when half of all firms ever active in the area entered the cluster. By this measure, early entry waves of electronics and manufacturing, were followed by further entries into instrumentation, IT, biotechnology, telecommunication and R&D.

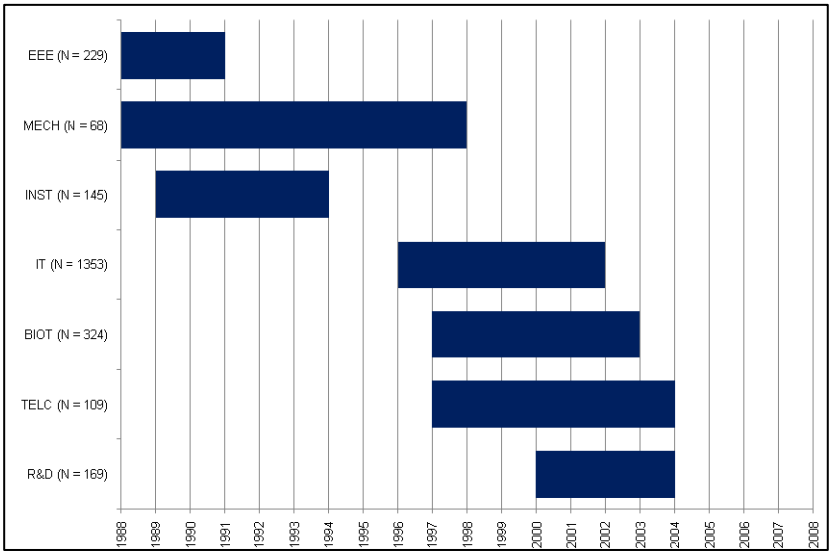

Figure 4 – Number of Firms and Employment in the Cambridge Cluster

Firm numbers were in part driven by spin-off activity from the University of Cambridge. Figure 4 illustrated the number of official spin-outs and unofficial start-ups from Cambridge University. While unofficial start-ups by members of the university (staff and graduates) outnumbered official start-ups in which the university held a stake, both types of firms provided a continuous supply of innovative technology-based firms to the cluster. Figure 5 includes the further spin-offs from previous university spin-offs that we were able to identify, providing evidence of the impact of serial enterprise.

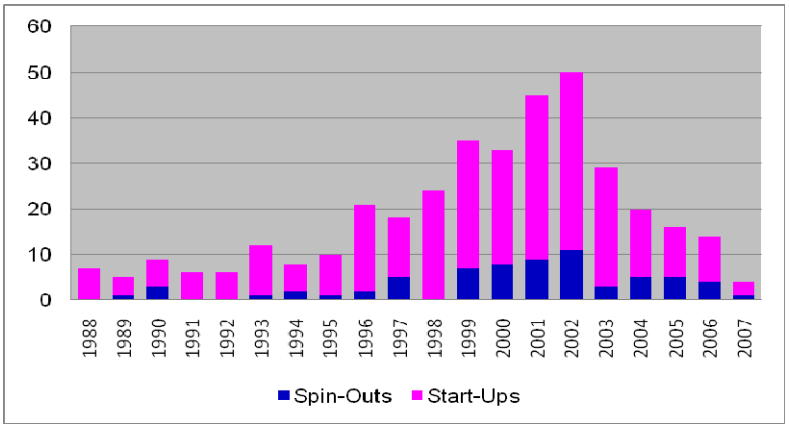

Figure 5 – Spin-Outs and Start-Ups from Cambridge University

Over time, high-growth firms made notable contributions to the employment and financial performance of the Cambridge cluster. Figure 6 indicates the share of high-growth firms in the employment and firm population of the Cambridge cluster. High-growth firms constituted a small number of firms until the mid 1990s, after when their share almost tripled. Following a

short downturn in the wake of the crisis of the early 2000s, high-growth firms have maintained their share in the total. Throughout the same period, high-growth firms became increasingly important employers. After a period of rapid expansion from the late 1980s until the late 1990s, high-growth firms continued to expand their prominence in the local labour market, albeit at a reduced rate.

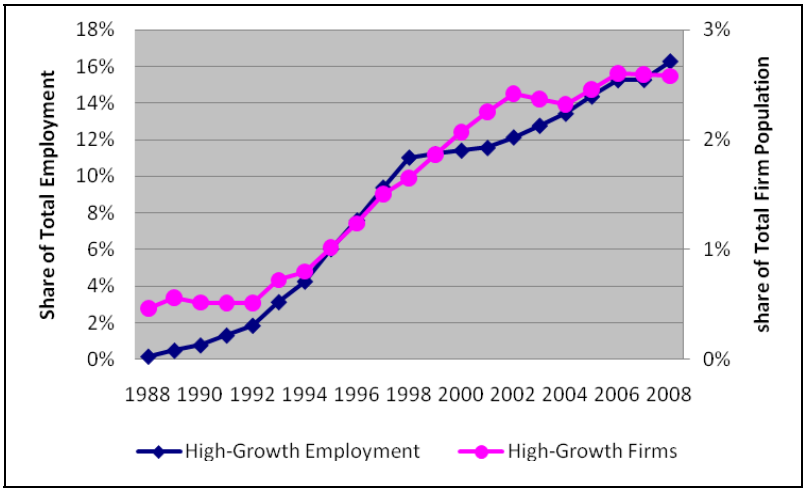

Figure 6 – Share of High-Growth Firms of Cluster Employment and Firm Numbers

High-growth firms consistently provided a percentage of employment that was greater than their share in numbers of firms, supporting Proposition 1. Figure 7 compares the overall employment changes in high-growth firms and in all firms in the tech cluster. During the early 1990s and 2000s, high-growth firms were creating employment at a time when there were job losses associated with downturns in the economy and were growing faster than average during years of economic upswing. Across the observation period, high-growth firms (there were 39 such firms by 2008), accounted for 24% of jobs created during this period, though these firms, growing at 20% or more pa., never made up more than 3% of the total of firms.

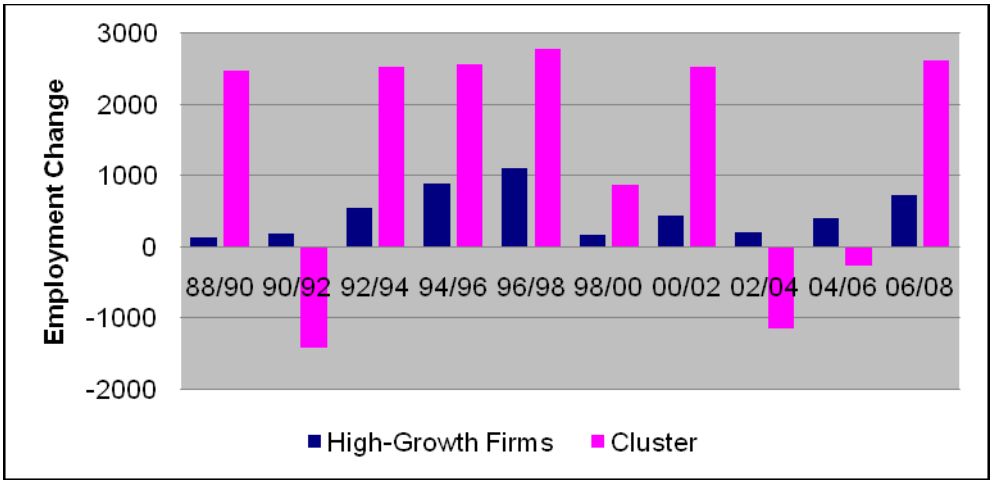

Figure 7 – Employment Development High-Growth Firms versus Cluster

4.2. Dynamic Elements in the Expansion of the Cluster

4.2.1. Turbulence measured by churn (entry/exit rates)

The overall figures on firm and employment numbers reflect the net effect of entries and exits. There is evidence to suggest that the larger firms in the area experienced growth reinforcement effects (Garnsey, 1998) while smaller firms, especially in sectors where barriers to entry were low, were more likely to be eliminated as the business cycle turned against them. Most recently, the uncertain economic climate appears to have deterred start ups, as shown in the figures for university spinoffs (figure 5) and by the following entry-exit analysis. The database has records for 104 new firms created between 2006 and 2008, shown in figure 8. This is only 37% of the peak total of 279 in 2002. But the number of lost firms was lower between 2006 and 2008 and new entries rose. These changes in numbers of firms and jobs are reflected in the falling and then rising mean size of employment per firm (Evans and Garnsey 2009).

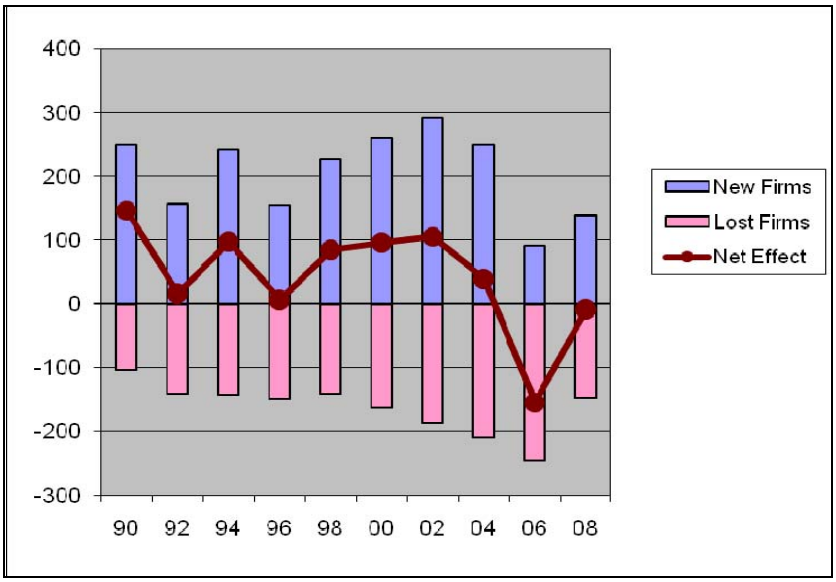

Figure 8 – Entry and Exit of Technology Firms in Cambridgeshire

Figure 9 shows the employment impact of turbulence in relation to that of firm growth. The net employment effects of entry and exit were sustained expansion during the 1990s, reaching a high point during the 2000s. However growth-related employment changes outweighed the effects of firm entry and exit. Thus proposition 2 is not supported. Over the observation period, firm growth amounted to two-thirds of all new job creation, while entry-exit related turbulence (net firm changes) accounted for one third of job creation. Accordingly, we turn next to growth of existing firms.

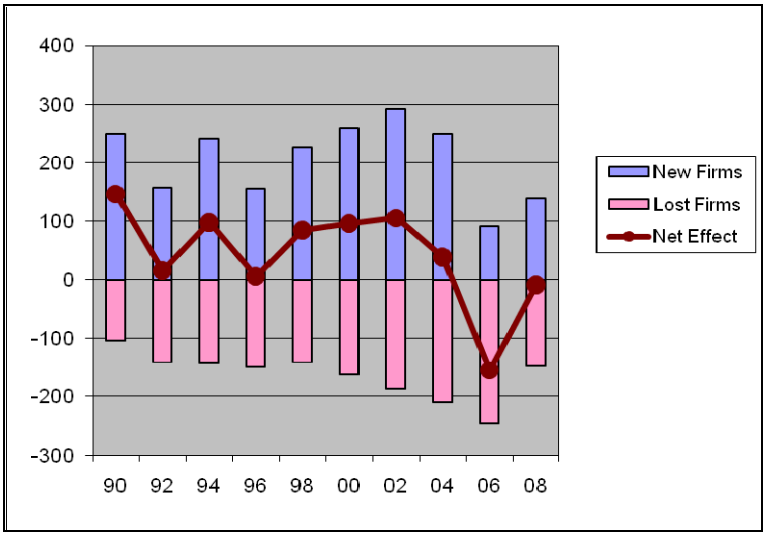

Figure 9 – Employment Effects of Firm Entries and Exits

4.2.2. Expansion of the Cluster through Organic Growth of Existing Firms

Expansion and elimination of firms are clearly evident in employment distribution. The analysis in figure 10 shows the employment distribution by the employment size of firms biennially from 2000 to 2008. This analysis shows that since 2004 there has been a fall in the proportion of employment in firms smaller than 10 people, congruent with the formation and collapse of a micro-firm bubble. This reflects the technology crash of 2000-2001 in the US, where many customer firms are located, especially in IT; there was a fall in numbers of IT start ups and IT firms with fewer than 5 employees after 2002. Over the period as a whole, the proportion of small firms declined in relation to midsized and larger firms, but small firms remained the most numerous category, a feature of firm size distribution nationally and internationally.

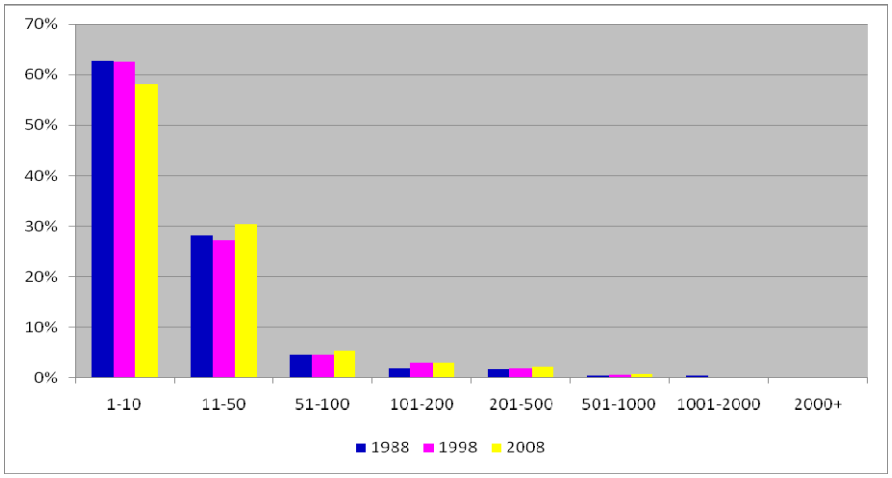

Figure 10 - Employment Distribution by Employment Size Categories

Figure 11 shows the impact of the micro-firm sector on aggregate employment, with the most recent proportion of employment in micro-firms at its lowest level at any stage in the past 20 years, following a boom and then decline in numbers of IT micro-firms. This sector has low entry barriers. This shakeout in the aftermath of the technology bubble of the early 2000s represented a return to trend in the development of the IT sector, following the tech boom (Garnsey and Drofiak, 2009). R&D and biotech sectors have grown and tend to be larger in size than the IT software or services companies.

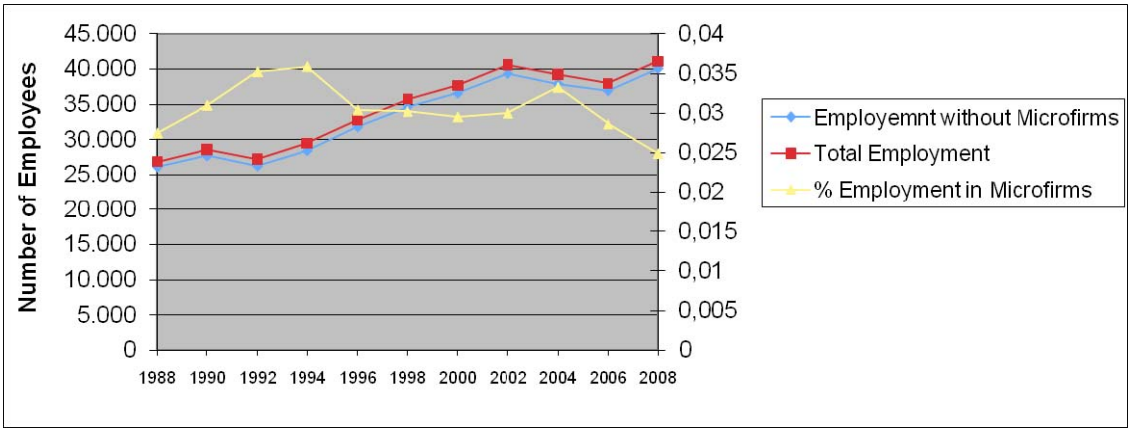

Figure 11 - Microfirm Impact upon the Cluster

What are the implications of the decline in start-up rates shown by churn analysis and the reduction in number of small vulnerable firms? So long as enough small firms are viable and growing, the size of the pool of smaller firms may not be salient. However it is necessary to carry out firm size transition analysis to trace the effects of changes in relative size distribution on the dynamics of the cluster.

We can isolate the processes by which firm size distribution has changed over the period by a form of transition analysis which shows the collective effect of firms passing through size categories as they grow or decline (figures 12a and 12b). Here we see the greater volatility of small firms compared to larger ones as regards size change, providing support for proposition 3.

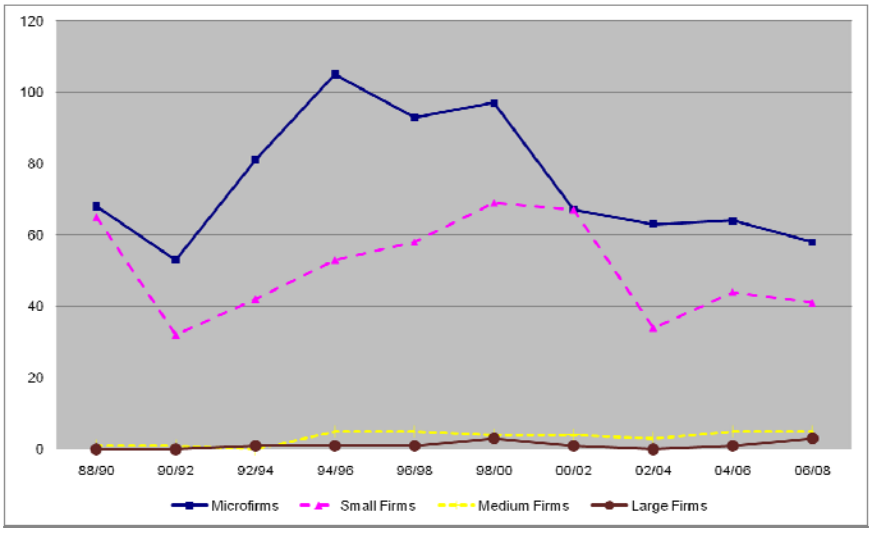

Figure 12a – Cambridge Technology Firm Size - Transition Analysis

Figure 12a uses the conventional size categories where the greater volatility of the smaller firms is partly an artifact of the classification system, since to register a change in size category requires a much greater absolute change in job numbers for the bigger firms. The smaller firms move more rapidly between size categories. Therefore we reclassified firms into even size categories (Figure 12b).

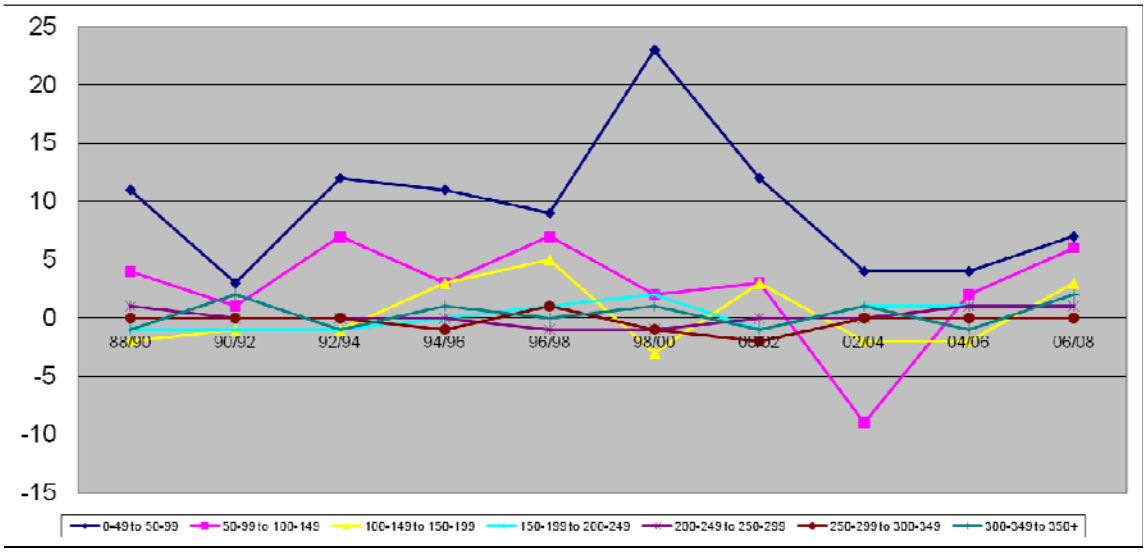

Figure 12b – Cambridge Technology Firm Size – Adjusted Transition Analysis

From figure 12b we see that the sensitivity of smaller Cambridge based hi-tech firms to business cycles is a real effect, not just the result of size categories. Mid-sized firms (50-149 and 100-199) also changed size categories to a greater extent than the larger firms. Since mid-sized categories were not replenished by new firm entries (which are mainly of small firms), they depend on replenishment by firms outgrowing smaller size categories. There were occasions when there was a net fall in numbers in midsized categories, especially between 2002 and 2006. This appeared to be a lagged effect, whereby fewer firms in the smallest category – eligible for growth into the next size category – was followed in the next survey period by a reduction in the number of firms moving up to next size category – that is, the midsized category was not being replenished by smaller firms growing to midsized. This points to the longer term implications for cluster growth of fewer small firms growing in size since mid-sized firms are more stable than smaller firms. For the cluster as a whole, however, employee growth in a few larger firms was able to offset job reductions in a much higher number of smaller firms, restoring the employment growth of the entire cluster by 2008 shown in figure 1.

The above calculations make it possible to identify the size categories that gave rise to high-growth firms (those with average growth rates of over 20% per year.) Of the 39 high growth firms in the Cambridge tech cluster, 17 began in the micro-firm category (fewer than 10 employees), 18 started with between 10-50 employees, and 4 firms began with more than 50 employees. It is firms with a larger than average start-up team (largest cases reflecting demerger effects or buyouts) that are most likely to realise rapid growth. This was also a finding by Reynolds and White in their extensive US study (1997).

Launch on the stock market (initial public offering, IPO) provided an exit route for investors in performing ventures, and a source of resources for independent growth. Among the 39 high-growth firms identified, over a quarter (11), achieved an IPO from among 75 IPOs that we identified in all Cambridge tech firms listing on a stock market over the period 1988 to 2008.

Four local start ups achieved outstanding performance, reaching over 1000 employees and become leading firms in their industries. They are Domino (ink jet printing), ARM (chip design), Autonomy (search engines) and Cambridge Silicon Radio (semiconductor). These firms shown together in figure 13 grew rapidly from 2003 to 2008, after a period of stability following the technology crash, reaching a combined turnover of £1.4b and providing over 6000 jobs in the area by 2008, almost 15% of all jobs. They demonstrate the importance of rapid growth which sets off growth reinforcement effects. However individually, each firm went through periods of setback (as shown elsewhere, e.g. Garnsey, Ferriani et al 2006). Firms' ability to overcome setbacks is no less important than rapid growth, but has received less attention in the literature.

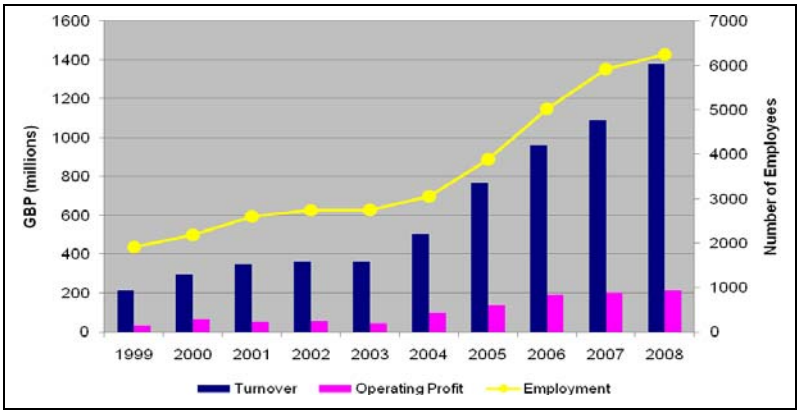

Figure 13 – Cumulative Impact of ARM, Autonomy, CSR and Domino

4.2.3. Growth Through Acquisition

Innovative Cambridge firms attracted both national and international acquirers. While acquisition by other firms was initially a rare occurrence among Cambridge technology firms, by the late 1990s, the incidence of acquisition was nearly double the rates of the 1980s (see figure 14). This increase could be observed for both acquisitions of Cambridge firms by other firms and for acquisitions made by Cambridge firms. About half of acquirers (46%) were foreign, 34% from the US. The markets for acquisition reflected business cycles. Thus, acquisition increased almost seven-fold during the technology boom of the late 1990s before declining during the early 2000s. Overriding business cycles, acquisition has attained growing prominence in the Cambridge technology cluster. Acquisition was important for founders and investors in realising the value of their enterprises. We were able to identify acquisition terms for 72 cases; for valuations that were disclosed the total exceeded £6 billion. It was not possible to identify beneficiaries of the deals or how returns were distributed.

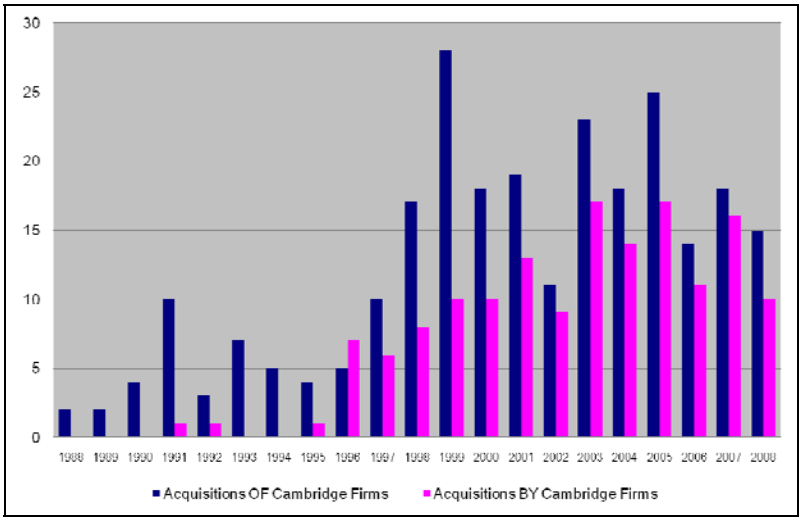

Figure 14 – Number of Acquisitions across six sectors per Year

High-growth firms were frequent acquisition targets. Overall, some 42%, of all high-growth firms were acquired. This compares with an incidence of 14% among all firms. Only 5% of all firms resorted to acquisitions as a means of growth (cf. Pasanen, 2007); this share was higher for high-growth firms, among which 50% of firms had acquired another firm. These patterns lend support propositions 4 and 5 which stated that high growth firms are more likely to be acquirers and to be acquired than other firms.

It is seldom possible to follow the same firm's growth from independence through to its status as a unit in the acquiring company. Performance data for the acquired unit is usually conflated with that of the acquiring firm. However we were able to gather public domain data on pre- and post-acquisition performance for Cambridge technology companies from the six sectors that accounted for most acquisitions. Improvements in profitability were frequently associated with restructuring that led to reduction in assets and employees, thus supporting proposition 6 (acquisitions were associated with job losses in the acquired units). Table 1 compares other performance indicators before and after acquisition. Over a three year period before and after takeover (right side of table 1), there was a small decrease in employment but a sizeable improvement in profitability and cash position for firms reporting data. The cumulative data (left side of table 1) shows a contrast between 38% growth in jobs before acquisition and 11% decline in jobs, afterwards. Growth in assets did not continue over the long term (left).

Dimension	Cumulative change before/after acquisition, all available data			3 Years pre/post acquisition		
	N	*Growth Before*	*Growth After*	*N*	*Growth Before*	*Growth After*
Turnover	34	247%	142%	11	438%	203%
Op. Profit	43	-413%	109%	16	-132%	20%
Assets	58	243%	0%	27	-58%	20%
Cash	49	902%	356%	19	128%	1241%
Employment	127	38%	-11%	76	12%	-1%

Table 1 – Reported Pre- and Post-Acquisition Growth of Cambridge Companies

The acquired firms had been experiencing rapid growth of sales, which diminished after takeover. Profitability and sales per employee increased but profits were liable to repatriation by foreign corporations. A release of assets and job reductions may stimulate entrepreneurial activity - with experienced employees leaving to join local start-ups and entrepreneurs founding post-acquisition spin-off companies. Spinoffs founded post-acquisition are vulnerable to economic volatility but benefit from the previous experience of founders.

Acquisition was an exit strategy favoured by venture capitalists; we have seen that the incidence of acquisition fell when venture capital availability decreased after 2004 (Garnsey and Drofiak 2009). In the case of biopharmaceutical firms in particular, those receiving VC were more likely to be acquired (Mohr and Garnsey, 2009). Acquisition enabled owners to realise value from their enterprise and investment. We have seen that for valuations that were disclosed (72 cases), the total exceeded £6 billion, but beneficiaries of these deals are difficult to identify. Thus while 9 spinouts partly owned by the university were acquired, the universities' share in the proceeds of the sale are not reported.

Limits of employment growth data

We were aware of the limits of assessing growth on the basis of job numbers, the standard firm growth measure (Davidsson and Wiklund, 2000; Sheperd and Wiklund, 2009). One reason why these data are commonly used is that they are much more readily available (Davidsson and Wiklund, 2000). It is difficult to collect other performance data over time for firms since earlier data are seldom archived. We assembled and tracked over time the financial performance of those 990 Cambridge firms for which financial performance data was in the public domain. These firms overlap with those in the database used for previous figures, but are a smaller total with a different distribution by size and sector (see method section). In consequence, we cannot generalise to the whole cluster from performance data for this dataset. However by virtue of having data in the public domain, they are the most prominent among the Cambridge area tech firms.

The firms in this dataset had by 2008 achieved turnover in excess of £5 billion and profits of £341 million, while employing some 30,926 employees locally. These data are summarised in figure 15, which shows that the firms as a whole became more profitable by 2005, while other performance measures deteriorated after 2006. This finding is congruent with evidence that the larger indigenous firms have been growing more profitable in the area. It is also congruent with almost half of the best performing firms in the area being acquired under conditions where short term profit rather than long term performance appeared to be the priority for acquirers.

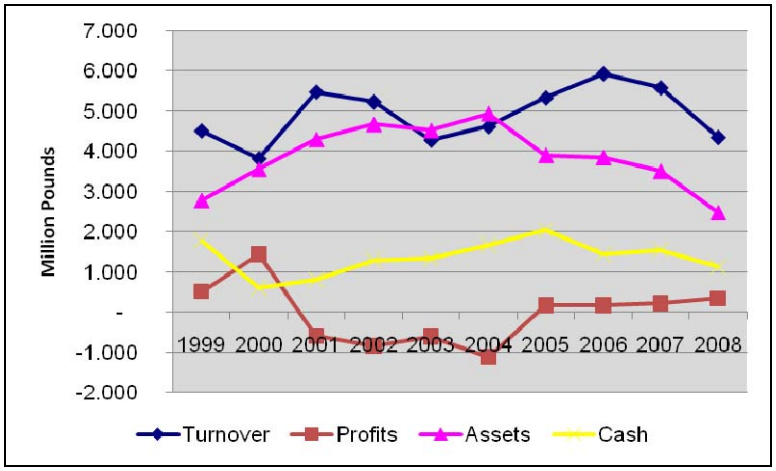

Figure 15 – Financial Performance Indicators in the Cambridge Cluster

We have seen that the number of new firms and firms growing from small to mid-sized declined after 2000; another sign that the technology crash of the new millennium was followed by a marked change in relevant indicators of business activity in the cluster is seen in patenting activity during the period (see figure 16).

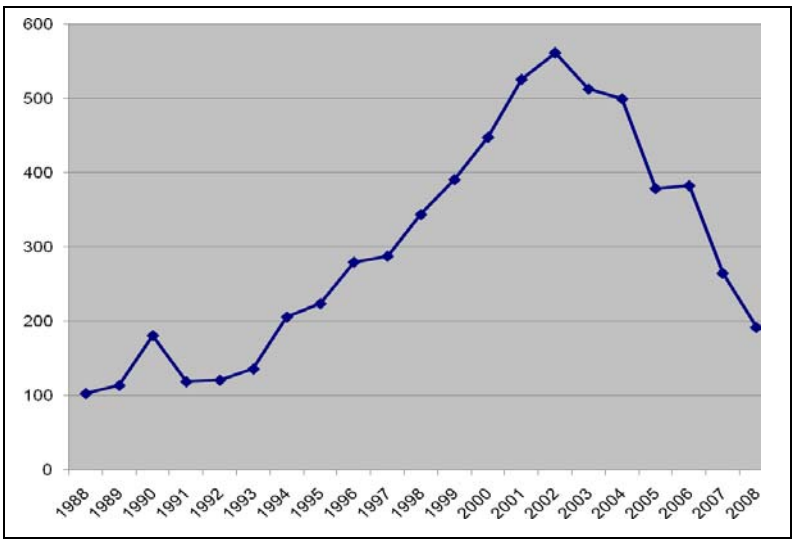

Figure 16 – Patenting Activity in the Cambridge Cluster

4.4. The Cambridge Cluster in Context

4.4.1. Cambridge and the Attraction of Firms

As outlined in the introduction, the growth of the Cambridge technology cluster has not been the outcome solely of endogenous growth. Over time, the Cambridge cluster has attracted technology firms from outside the cluster. These firms have played an important role in providing support services, managerial talent, and exposure to external firms seeking to collaborate with Cambridge-based technology enterprises. We assessed the contribution of locally founded firms and firms attracted to Cambridge employment in technology firms, summarized by date in figure 17. Jobs in attracted firms have grown less fast but been less cyclical than in locally founded firms.

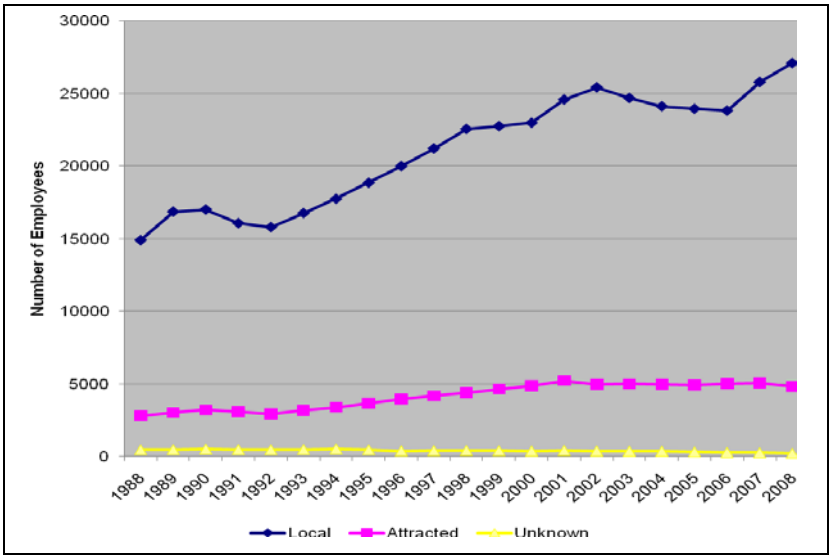

Figure 17 – Local and Attracted Employment in Cambridge

4.4.2. The Cambridge Cluster and Silicon Valley

To set the Cambridge cluster in international context, we investigated available evidence for a comparison with Silicon Valley. Although the Cambridge cluster is only around 1/35th the size of Silicon Valley in terms of employment, Silicon Valley is often used as a comparator. The Cambridgeshire County had a population of 598,000 in mid 2007 whereas Silicon Valley had a population of 2.52 million at the end of 2008. High tech employment in these areas is shown in figure 18; no other comparable data are available.

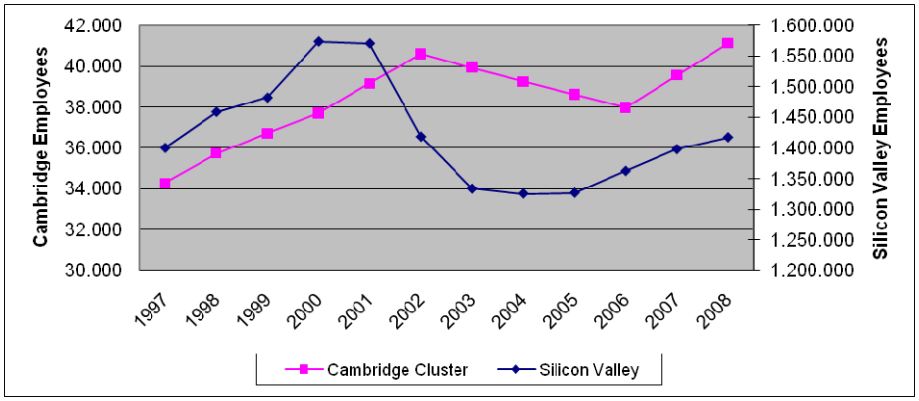

Figure 18 - Total Employment in Silicon Valley and the Cambridge Cluster

Figure 19 shows the impact of the end of the "technology bubble" during the early 2000s on employment in both clusters. The Silicon Valley data shows a decline of approximately 100,000 jobs from a plateau in 2000-01 before a recovery from 2005. The Cambridge data suggests a peak in 2002 and a fall of 3,000 jobs until 2007 when a recovery commenced. Comparative resilience in terms of jobs can be seen more clearly if growth is calculated in proportional not absolute terms (figure 20), with 1998 firm numbers in each area set at 100. Cost cutting may have been more rapid in Silicon Valley.

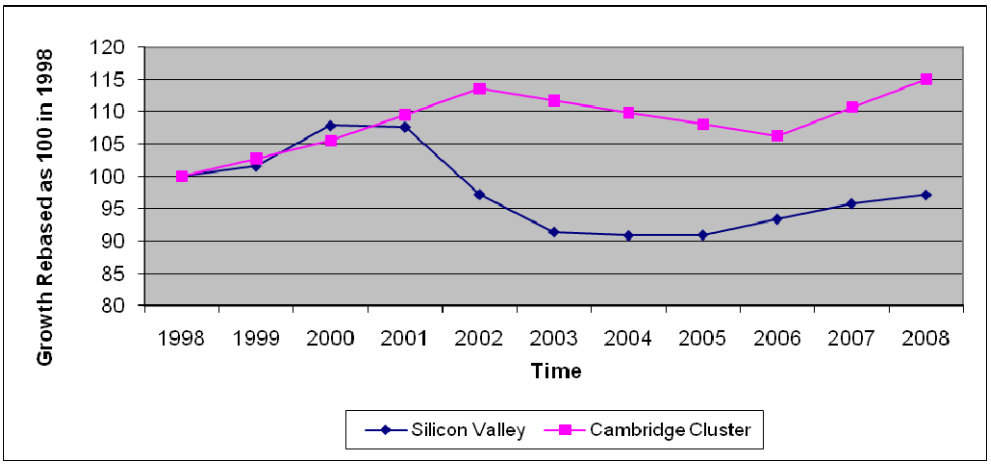

Figure 19 - Employment in Silicon Valley and Cambridge Rebased as 100 in 1998

The rebased graph in figure 4 shows that the downturn in Silicon Valley was deeper than in Greater Cambridge, as employment fell to approximately 91% of its 1998 figure whereas Cambridge tech-based firm numbers did not fall below 105% of its 1998 value. The downturn in Silicon Valley was especially dramatic for Internet firms, of which there were fewer in Cambridge. Sales outside the US were an aid to recovery in the US-centered recession of the technology crash, post-millennium. Once a recession extends globally, international markets may no longer provide a relative advantage to Cambridge firms. Moreover we pointed to a number of causes of concern over the Cambridge cluster, which we take up below.

5. Findings

The guiding propositions are summarised below in Table 4 and discussed in relation to the findings.

Item	Proposition	Findings
P1	High growth firms had a disproportionate impact on employment growth in the cluster.	Yes
P2	The employment contribution to the cluster of net entry-exit of firms was greater than that of firm growth.	No
P3	Small firms exhibited great growth volatility than large firms	Yes (real and category effect)
P4	High-growth firms were more active acquirers than other firms	Yes
P5	High-growth firms more frequently acquired than other firms.	Yes
P6	Acquisitions resulted in job losses in acquired firms.	Yes

Table 2 – Summary of Findings in Relation to Propositions

High-growth firms contributed disproportionately to cluster employment during periods of upswing but were also important in maintaining growth during periods when the cluster at large contracted (proposition 1). In contrast, the net effect of new entries and exits (creative destruction), assumed in proposition 2 to be more important than continuing growth, in fact had less of an impact on employment growth in the cluster than did the growth of incumbent firms. In the Cambridge tech cluster, firm growth contributed two-thirds of all new job creation 1988-2008, while entry-exit turbulence accounted for one third of job creation. Larger firms showed less volatile growth than smaller ones, as predicted by proposition 3. However the evidence is not such as to prove that the growth of successful innovative firms in the area was at the expense of less innovative firms. It may be that adverse conditions prevented some innovative small firms from reaching mid-size following the technology crash. Nevertheless, the increasing number of larger firms that emerged in the cluster reduced vulnerability to business downswings for employment in the cluster. The turbulence of the period studies certainly redirected some resources, talents and ideas to firms that could use them to advance further growth. The ability of firms to overcome growth setbacks and sustain their growth after an interruption was critical for the cluster.

Acquisition is another dimension of turbulence, affecting entry and exit. Propositions 4 and 5 led us to expect high-growth firms to be actively involved in takeovers, as acquirers and acquired. While evidence on the impact of acquisitions is very limited, it is well known that corporate acquirers attempt to introduce more professional management systems and operations (Galpin and Herndon, 2007). This should enable the acquired unit to grow more profitable with fewer inputs of employees and other assets. Our evidence is consistent with such developments. However there may also be an element of destruction in the turbulence of acquisition. High performing firms were particularly likely to be acquired, followed by job losses, asset reduction and liability of repatriation of profits by foreign owners. Corporate managers took the place of founder entrepreneurs as final decision makers, in contrast with US companies like Microsoft, Oracle and Google where founder managers continued to drive strategy. Post acquisition spinoff effects require further investigation. A positive effect of such spinoffs is the new entry effect, as those selling their firms to acquirers start out new firms, so increasing the pool of firms eligible for growth into larger categories.

5.2. Reflections on creative destruction

We have analysed three closely related constituents of growth: entry of firms versus exit of firms, organic growth and growth through acquisition, using longitudinal evidence. To this end, we departed from cross-sectional studies that dominate most prior work. We used churn analysis to gain a better understanding of the impact of creative destruction on the growth of Cambridge firms. Transition analysis from one size category to another revealed proportionately fewer small firms growing into larger size categories. Acquisition is another form of turbulence, eliminating the independence of acquired firms. We found that the best performing firms in the cluster were more likely to be acquired.

This paper is centred on new findings and does not attempt a reassessment of the Cambridge cluster, examined elsewhere (Garnsey and Heffernan 2005; Drofiak and Garnsey 2009; Evans and Garnsey 2009). There is a consensus among cluster studies that positive externalities are enjoyed by firms through participation in a cluster (Audretsch and Feldman, 1996; Feldman, 1999; Feldman, Francis and Bercovitz, 2005). Smaller suppliers benefit from the presence of larger local companies through positive externalities. We have shown elsewhere how Domino Printing Sciences provided custom for local suppliers (Garnsey, Thomas and Stam, 2009). The findings reported here on the 'big four' indigenous tech firms show how important such firms are for a cluster. The four firms have operated as learning centres where over 6000 employees have gained critical experience of rapid and sustained growth in international markets.

The data presented here are from the eve of the financial crisis, for benchmarking with further survey details when these become available. We have seen that average firm size increased and that profitability improved among larger firms in the Cambridge tech cluster. This can be interpreted as an adaptation to economic conditions, and a reflection of the operation of some form of creative destruction. Schumpeter recognised that small firms were highly vulnerable, even though a few of them grow in such a way as to displace established rivals (Schumpeter 1928). In the short term and during a downturn, fewer microfirms imply fewer firms vulnerable to recession. Just as in the plant world, new shoots are 'switched off" under adverse environmental conditions (Harberd, 2006), so a reduction in the proportion of very small and vulnerable firms in the cluster may reflect an adaptation to a difficult economic environment. The larger firms providing more local jobs in uncertain times may reduce the incentive to potential entrepreneurs to start new firms. In the longer term, there may be compensating effects at work if those fewer firms that are started during a recession prove to be unusually robust. We have shown elsewhere that there were very high survival rates among the cohort firms founded in the recession of the early 1990s; low entry rates can be compensated for when economic conditions improve (Drofiak and Garnsey 2009). However a prolonged recession may prevent such recovery.

We have identified a lagged effect whereby a reduction in the pool of smaller firms was followed in the next survey period by a reduction in the number of midsized companies. In the past the most successful Cambridge tech firms went through a period of being mid-sized. A reduction in the mid sized category implies a reduction in the pool eligible to move into larger size categories. Through their impact on firms' moves up size categories, business cycles effects may persist over time in the absence of policy input to remedy constraints experienced by young knowledge based firms. If these firms are as important for the economy as generally assumed, considerable effort should be devoted to pilot policies to provide favourable conditions for their growth.

Acknowledgements

We would like to thank the County Council Research Group for enabling us to be part of the team working on the company confidential Cambridge high tech database. This paper builds on work by Alex Drofiak and Mark Evans, whose recent contributions illuminated both the limits and the potential of the database used here.

A version of this paper was presented at the Scottish Regional Studies Association Conference."Gazelles and Regional Development." 7-8 June, 2010. University of Stirling.

6721 words

References

Acs, Z.J. and Mueller, P., 2008. Employment effects of business dynamics: Mice, gazelles and elephants. *Small Business Economics*, 30(1), 85–100.

Audretsch, D.B. and M.P. Feldman, 1996. R&D Spillovers and the Geography of Innovation and Production. *American Economic Review*, 86, 630-640.

Arthur, W.B., 1989. Competing Technologies, Increasing Returns and Lock-in by Historical Events. *Economic Journal*, 99, 106-131.

Birch, D.L., 1979. *The job generation process. MIT program on neighborhood and regional change,* Cambridge, MA: Massachusetts Institute of Technology.

Birch, David L. (1981). Who Creates Jobs? *The Public Interest*, 65, 3-14.

Bullock, A., Cosh, A., Fu, X., Hughes, a. and Yang, Q., 2004. *SME Growth Trajectories A pilot study of UK SME growth and survival using the CBR panel data*. Centre for Business Research, Cambridge University.

Chaudhuri, S. and Tabrizi, B., 1999. Capturing the real value in high-tech acquisitions. *Harvard Business Review*, 75 (5), 123-130.

Connell, D. and Probert, J., 2010. *Exploding the Myths of UK Innovation Policy: How 'Soft Companies' and R&D Contracts for Customers Drive the Growth of the Hi-Tech Economy*. Centre for Business Research, Cambridge.

Davidsson, P. and Wiklund, J., 2000. Conceptual and empirical challenges in the study of firm growth. In Sexton, D. and Landström, H. (eds.): *The Blackwell Handbook of Entrepreneurship*. Oxford, MA: Blackwell Business.

Davidsson, P. and Wiklund, J., 2006. Conceptual and Empirical Challenges in the Study of Firm Growth. In: Davidsson, P., Delmar, F. and Wiklund, J., (eds.): *Entrepreneurship and the Growth of Firms*. Cheltenham, UK: Edward Elgar, pp. 39-61.

DeTienne, D.W. 2010, Entrepreneurial exit as a critical component of the entrepreneurial process: Theoretical development, *Journal of Business Venturing*, 25(2), 203-215.

Diambeidou, M.B., 2008. *An Empirical Taxonomy of Early Growth Trajectories*. Doctoral Dissertation, Université catholique de Louvain, Louvain School of Management: Belgium.

Dougherty, D. and Heller, T., 1994. The Illegitimacy of Successful Product Innovation in Established Firms. *Organization Science*, 5 (2), 200-218.

Drofiak, A. and Garnsey, E., 2009. *The Cambridge High Tech Cluster: resilience and response to cyclical trends*. Institute for Manufacturing Working Paper 2009/01. Institute for Manufacturing, University of Cambridge, UK.

European Union, 2004. *Facing The Challenge. The Lisbon strategy for growth and employment*. Report from the High Level Group chaired by Wim Kok. Available at: <http://ec.europa.eu/growthandjobs/pdf/kok_report_en.pdf>

Feldman, M.P., 1999. The New Economics of Innovation, Spillovers and Agglomeration: A Review of Empirical Studies. *The Economics of Innovation and New Technology*, 8, 5-25.

Feldman, M.P., J. Francis, and J. Bercovitz, 2005. Creating a Cluster While Building a Firm: Entrepreneurs and the Formation of Industrial Clusters". *Regional Studies*, 39, 129-141.

Frederick, H.H., 2004. Towards high growth enterprise. *International Journal of Entrepreneurship and Small Business*, 1(3/4), 238-248.

Galpin, T.J. and Herndon, M., 2007. The Complete Guide to Mergers and Acquisitions. *San Francisco*: Jossey-Bass.

Garnsey, E., 1998. A theory of the early growth of the firm. *Industrial and Corporate Change*, 7(3), 523-556.

Garnsey, E. and Heffernan, P., 2005. Growth Setbacks in New Firms. *Futures*, 37, 675-697.

Garnsey, E. and Mohr, V., 2010. *When Stars Stumble: Growth Sustainability in Rapid-Growth Firms*. Unpublished Working Paper. Institute for Manufacturing, Cambridge, UK.

Garnsey E., Ferriani S. and Lorenzoni G., 2008. Speciation through entrepreneurial spin-off: The Acorn-ARM story. *Research Policy*, 37, 210- 224.

Garnsey, E., Thomas, B. and Stam, E., 2009. *The emergence and development of the Cambridge inkjet printing industry*. Institute for Manufacturing Working Paper 2009/04. Institute for Manufacturing, University of Cambridge, UK.

Gibrat, R., 1931. *Les Inégalités Économiques*. Paris: Sirey.

Graebner, M.E. and Eisenhardt, K.M., 2004. The Seller's Side of the Story: Acquisition as Courtship and Governance as Syndicate in Entrepreneurial Firms. *Administrative Science Quarterly*, 49(3), 366-403.

Granstrand, O. and Sjölander, S., 1990. The Acquisition of Technology and Small Firms by Large Firms. *Journal of Economic Behaviour and Organization*, 13 (3), 367-386.

Hagedoorn, J. and Duysters, G., 2002. The effect of Mergers and Acquisiton on the Technological Performance of Companies in a High-Tech Environment. *Technology Analysis and Strategic Management*, 14(1), 67-85.

Harberd, N., 2006. *Seed to Seed: The Secret Life of Plants*. London: Bloomsbury.

Henrekson, M. and Johansson, D, 2009 . Gazelles as job creators: a survey and interpretation of the evidence. *Small Business Economics*, forthcoming.

HM Government Department for Business, Innovation and Skills (BIS), 2010. *Going for*

Growth.

HM Government Department of Business, Enterprise and Regulatory Reform (BERR), 2009. *New Industry, New Jobs*.

Hölzl, W., 2009. Is the R&D behaviour of fast-growing SMEs different? Evidence from CIS III data for 16 countries. *Small Business Economics*, 33(1), 59-75.

Hugo, O. and Garnsey, E., 2004. Problem-solving and competence creation in new firms. *Managerial and Decision Economics*, 26(2), 139-148.

Jovanovic, B., 2001. New Technology and The Small Firm. *Small Business Economics*, 16(1), 53-56.

Julien, P.-A., 2007. *A Theory of Local Entrepreneurship in the Knowledge Economy*. Cheltemhan, UK: Edward Elgar.

Lim, S. S., Platts, K. and Minshall, T.H.W., 2008. *An exploratory study on manufacturing strategy formulation in start-up companies*. 16th High Technology Small Firms Conference. Enschede, The Netherlands, University of Twente.

Mason, C.M. and Harrison, R.T., 2006. After the exit: Acquisitions, entrepreneurial recycling and regional economic development. *Regional Studies*, 40(1), 55-73.

McKelvie, A. and Wiklund, J., 2010. Advancing Firm Growth Research: A Focus on Growth Mode Instead of Growth Rate. *Entrepreneurship Theory and Practice*, 34(2), 261-288.

Mohr, V. and Garnsey, E., 2009. *Acquisition as Business Opportunity for Bio-pharm Ventures A Resource-Based Evolutionary Perspective*. Unpublished Working Paper. Institute for Manufacturing, Cambridge, UK.

Moreno, A.M. and Casillas, J.C., 2005. *High Growth Enterprises (Gazelles): An Conceptual Framework*. Available at: <http://ecsocman.edu.ru/images/pubs/2005/04/26/0000209801/high_growth.pdf>

Owen, G. (2004) *Where are the big gorillas? High technology entrepreneurship in the UK and the role of public policy*. Discussion paper Interdisciplinary Institute of Management, London School of Economics .

Parker, C., van Witteloostuijn, A. and Storey, D.J., forthcoming 2010. What happens to gazelles. *Small Business Economics*.

Penrose, E., 1995. A Theory of the Growth of the Firm (2nd edition).Oxford, UK: Oxford University Press.

Ranft, A.L. and Lord, M.D., 2002. Acquiring New Technologies and Capabilities: A Grounded Model of Acquisition Implementation. *Organization Science*, 13(4), 420-441.

Reynolds, P.d. and White, S.B., 1997. The Entrepreneurial Process: Economic Growth, Men, Women, and Minorities. Westport, CT: Quorum Books.

Sarkar, M.B., Echambadi, R., Agarwal, R. and Sen, B., 2006. effect of the innovative environment on exit of entrepreneurial firms. *Strategic Management Journal*, 27(6), 519-539.

Schumpeter, J.A. 1939. *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*. New York and London: McGraw-Hill.

Segal, Quince and Partners, 1985. *The Cambridge Phenomenon: The Growth of High Technology Industry in a University Town*. Cambridge, UK: Segal Quince & Partners.

Sheperd, D. and Wiklund, J., 2009. Are we comparing apples with apples or apples with oranges? Appropriateness of knowledge accumulation across growth studies. *Entrepreneurship Theory and Practice*, 33(1), 105-123.

St.-Jean, E., Julien, P.-A. and Audet, J., 2008. Factors Associated with Growth Changes in "Gazelles". *Journal of Enterprising Culture*, 16(2), 161-188.

Stam, E., 2005. The Geography of Gazelles in the Netherlands. *Tijdschrift voor Economische en Sociale Geografie*, 96(1), 121–127.

Storey, D.J., 1994. *Understanding the small business sector*. London: Routledge.