Institute for Manufacturing

Centre for Technology Management

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No: 2007/04, April 2007

UNIVERSITY OF CAMBRIDGE

Centre for Technology Management Working Paper Series

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ISBN 978-1-902546-58-2

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Abstract

This paper reviews the literature on knowledge as a source of entrepreneurial opportunities, with evidence at both the regional and organizational levels. In addition the causal mechanisms of new firm growth are explored, discussing longitudinal case study research on problem-solving and competence creation in such firms.

Keywords: entrepreneurship, knowledge economy, sources of entrepreneurial opportunities, new firm formation, new firm growth.

Introduction

If the industrial economy ran on coal and iron ore, the fuel of today's economy is knowledge.[1] Technologies have always been underpinned by knowledge, but an economy run on knowledge is characterised by a critical role for information and communication technology (ICT), a high proportion of knowledge-intensive activity and intangible capital that amounts to more than tangible capital in the economy's capital stock (Atkinson and Court 1998; Foray 2004).[2] The emergence of the knowledge economy is not confined to high-technology and ICT services; it has spread across all sectors of market economies since the 1970s.[3] Wealth creation increasingly depends on the generation and exploitation of knowledge involving not only science and technology but also knowledge of practice required to create economic value (Gibbons et al. 1994). That knowledge plays an important role in the economy is not a new idea or finding. Every economy is based on knowledge of farming, mining, and construction (Mokyr 2002). Knowledge, embodied in people and technology has always been central to economic development. But only over recent decades has its importance received so much emphasis (Harris 2001). The OECD economies are more than ever dependent on the production, distribution and use of knowledge (OECD 1996).

While scholars in the 1950s and 1960s pointed to the economic importance of large firms (Galbraith 1956; Servan-Schreiber 1968), more recently a shift from the managed

[1] In policy terms this is reflected in respectively the European Coal and Steel Community (the forerunner of the current European Union) and the current Lisbon Strategy of the EU.
[2] The OECD (2005) defines the "knowledge based economy" as an expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors.
[3] Ironically, this has gone hand in hand with a labour productivity growth slowdown in Europe ever since, and initially also in the US (Van Ark 2000).

economy to the entrepreneurial economy in OECD countries has been identified (Audretsch and Thurik 2000; 2001). Radical changes in ICT and biotechnology have created market opportunities that are more effectively developed by new firms than by established companies. The shift to knowledge-based economic activity is said to be the driving force underlying the emergence of the entrepreneurial economy (Audretsch and Thurik 2001).[4] There is an emphasis on individual motivation, new ideas and risk taking, which render small and new flexible firms critical to economic success.[5] In the entrepreneurial economy, flexibility and innovation are more important than stability and control. Policy makers are counting on entrepreneurial initiative to address contemporary economic problems associated with structural change, including unemployment and industrial stagnation. Several studies have found that (especially ambitious) new firms have a positive effect on economic growth in advanced capitalist economies and to a marked extent in transition economies (Van Stel et al. 2005; Wong et al. 2005; Acs and Mueller 2006; Stam et al. 2007; Bosma et al. 2006). This is not the case in developing countries where other mechanisms are currently more important for economic growth (cf. Bwalya, 2006).

Recently comparative data has been amassed on entrepreneurship and young firm growth in different countries. Figure 1 shows indicators of entrepreneurship and young firm growth in several knowledge-based economies. The indicators of ambitious entrepreneurship and total entrepreneurial activity vary to a large degree (with Japan having values that are about five times smaller than the US). Within the UK, about 5

[4] A reverse causality has also been suggested: entrepreneurship driving the transition towards a knowledge-based economy (DTI 1998).
[5] In the knowledge economy, (innovative) new firms might be more important than small firms in general (cf. Parker 2001).

percent of the adult population is actively preparing a start-up or owns a recently started (<42 months) business. Slightly more than 1 percent of the adult UK population has the ambition to start a business that will expand beyond 20 employees. The indicator of young firm growth shows extensive variation: about 9 percent of the US young firms has grown by more than 60 percent while this is only the case for about 1 percent of the German firms. Figure 1 shows indicators of entrepreneurship and young firm growth. Japan has the lowest values on most indicators , and the US has the highest values. The UK and Italy also have high shares of high-growth young firms, while the Netherlands, Denmark, Norway and Germany reveal relatively low rates of realized growth. Ambitious entrepreneurs in the latter four countries face either well-paid competing opportunities or severe constraints that frustrate the realization of their growth ambitions.

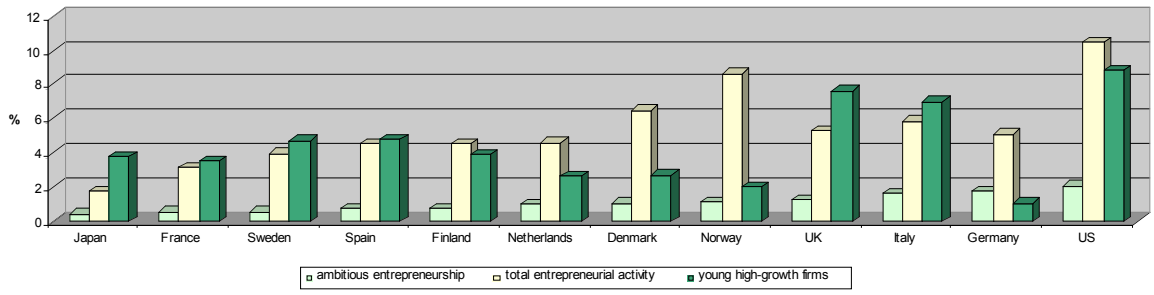

Figure 1. Entrepreneurship, growth ambitions and high-growth firms: an international comparison[6]

[6] Sources: Ambitious Entrepreneurship [20+ employees] and Total Entrepreneurial Activity [nascent entrepreneurs + owners of young (<42 months) businesses] in 2001 (Stam et al. 2007, based on GEM data), High-growth firms [at least 60 % employment growth over 3 years of young (<5 years) firms in with 15-200 employees, on average in 1999-2001] (Hoffmann and Junge 2006, based on Bureau van Dijk data)

In the international comparisons, the US stands out on all indicators of entrepreneurship and firm growth. This is usually attributed to cultural factors, which are doubtless present. Historically, innovations have been pioneered in the US since the 19th century. But the US benefits from three further advantages: a large and competitive domestic market; a highly developed financial system and a high level of long term government support for basic science (Owen 2004). The disadvantage of small home markets has been only partially offset by the removal of trade barriers within the European Union, given strong differences in language and national practice. The scale of US government support for scientific research, for defence-related and health-related research remains above that in European Union as a whole (Shahid and Kaora, 2007). Moreover government support to small business has been very extensive in the US (Connell 2006). Policy in the UK and other European countries has been influenced by "level playing field" considerations which would view US levels of support to companies by governments in member states as anti-competitive practices (cf. Dosi et al. 2006). Another remarkable fact is that countries that score high on R&D indicators and productivity levels, like Japan and Sweden, seemingly realise this without the 'intervention' of high levels of entrepreneurship.

Attention to the role of enterprise in the knowledge economy has resulted in policy makers around the globe counting on entrepreneurship to provide the engine of economic growth. A major source of entrepreneurial innovation is the knowledge developed in scientific organizations and private research labs. Entrepreneurs build on significant discoveries and emergent knowledge in their scientific communities (Merton 1993). Extensive investments in science and technology have given rise to opportunities

for innovation pursued by entrepreneurs (Baumol 2002). Whether or not opportunities are taken up successfully, however, depends on entrepreneurial behaviour in an economy and the way in which new businesses are managed. New firms have to create a resource base in order to commercialise knowledge on a scale that can make an impact. New firms excel at detecting opportunities and resourcing ventures but matching these up is a delicate process. This is reflected in the highly non-linear growth paths of new firms and high exit rates.

As knowledge-based firms enter, grow and exit the economy, they demonstrate the economic value of new knowledge. An economy with a high proportion of knowledge-based firms is building the knowledge and expertise required for the future when emerging technologies will diffuse into other parts of the economy. As Penrose (1995) pointed out, new firms are often the lead innovators in new fast growth industries devoted to the production of new goods and services (e.g. since her time, in communications). Their emerging technologies are subsequently diffused through intersectoral flows (see e.g. Mowery and Rosenberg 1998). The experimental nature of new firms and their role in the diffusion of new technologies are important reasons why the encouragement of knowledge-based entrepreneurship should be a policy objective (Rosenberg and Birdzell 1986; Rosenberg 1992; Eliasson 1998). Such firms may benefit from early entry into new markets and establish technological leadership (Mowery and Nelson 1999).

This paper deals with entrepreneurship in the knowledge economy. It reviews the literature on scientific and technological knowledge as a source of entrepreneurial

opportunities, examining evidence at both the regional and organizational levels. Because knowledge based firms have more impact on the economy if they grow, we review studies that have analysed the determinants of new firm growth.[7] In addition we focus on the causal mechanisms of new firm growth, discussing longitudinal case study research on problem-solving and competence creation in new growing firms. We end with a summary and a discussion on policy issues related to entrepreneurship in the knowledge economy.

Knowledge as a source of entrepreneurial opportunities

Entrepreneurship necessarily involves individuals and their response to economic opportunities (Shane and Eckhardt 2003). Not only is the source of opportunities important, but the nature of the individual recognizing and commercializing these opportunities. Studies have shown that entrepreneurial opportunities are not exogenously given but rather endogenously and systematically created under certain conditions. They are the outcome of investments in new knowledge and ideas (Schumpeter 1942) on the one hand, and the accumulation of knowledge in individuals (Shane 2000) and firms (Cohen and Levinthal 1989; 1990) on the other hand. Prior knowledge enables certain entrepreneurs to be alert to new opportunities (Shane 2000; Kirzner 1973).

[7] It has been said that the UK has been 'producing' too many university spin-offs, but not enough growing spin-offs, which are needed to commercialise new knowledge on a sufficiently large scale (Lambert 2003). In a similar vein, Owen (2004) showed that in comparison with the US the UK does not lag behind in the number of high-tech start-ups, but that the UK has a lack of technology-based firms which grow very fast from start-up into major international corporations (see also Bartelsman et al. 2005 for a lack of post-entry growth of successful entrants in European countries in general).

Prevailing theories of entrepreneurship have revolved around the ability of individuals to recognize opportunities and act on them by starting a new firm. This has generated a literature asking why entrepreneurial behaviour varies across individuals with different characteristics, while implicitly holding constant the external context in which individuals find themselves. Here the source of opportunities is implicitly taken as given. However it is unlikely that individual personality is the key factor in view of evidence that the entrepreneurial role is often set aside when individuals risk losing what they have gained from being entrepreneurial. Entrepreneurial start-ups often become conservative small businesses.

There has been much empirical research showing that firms located near knowledge sources introduce innovations at a faster rate than rival firms located elsewhere. These studies frequently invoke the existence of localised knowledge spillovers as an explanation for this correlation (see Breschi and Lissoni 2001 for a critical review). Agents investing in research or technology development often end up facilitating other agents' innovation efforts, either unintentionally, as when inventions can be imitated, or intentionally as where scientists report on their research. Economists have termed this non-rival characteristic of knowledge 'knowledge spillovers' (Arrow 1962; Nelson 1959). Knowledge spillovers have been defined as "any original, valuable knowledge generated somewhere that becomes accessible to external agents, whether it be knowledge fully characterizing an innovation or knowledge of a more intermediate sort. This knowledge is absorbed by an individual or group other than the originator" (Foray (2004, 91).

The generation of knowledge in centres of research does not automatically lead to new economic value. New ideas and knowledge embodied in goods and services need to reach markets and meet demand. Routes to market can be established by corporate marketing and, less readily, by technology transfer units of public organizations. The knowledge spillover theory of entrepreneurship (KSTE) suggests that entrepreneurship provides a crucial mechanism in translating knowledge into new value, and ultimately economic growth (Acs et al. 2005; Audretsch and Lehmann 2005b; Audretsch et al. 2006). In contrast with entrepreneurial traits theories[8], knowledge spillover theory takes individual characteristics as given and examines variation in context. One justification is that the same individuals move in and out of entrepreneurial roles over time. Moreover the knowledge context is held to influence cognitive processes. Endogenous entrepreneurship is said to occur when knowledge workers respond to opportunities by starting a new firm. In this view entrepreneurship is a rational choice made by economic agents who seek to appropriate the value they attribute to knowledge endowments, whether their own or their employers'. This theory does not claim that entrepreneurship is the only mechanism for turning formal knowledge into economically valuable knowledge but attempts to throw light on this particular mechanism.

In principle, established companies are better placed to exploit opportunities as they have more resources to deploy than new ones. But as Penrose pointed out in 1959, the established company faces constraints in perceiving and responding to new opportunities. Its managers 'will be guided in its expansion programmes as much by the nature of its own resources as by market demand, for every firm is … a more or less

[8] The psychological traits associated with entrepreneurial behaviour - independence, achievement needs, tolerance of ambiguity, persistence etc. - help people to survive and get on everywhere, as shown by the success of micro-credit schemes in developing countries (Prahalad 2004).

specialised collection of resources and cannot move with equal ease in every direction' (Penrose, 1995, p.224). Penrose wrote that there are in consequence opportunities for small firms to arise in the interstices neglected by large companies. Potential entrepreneurs may recognize opportunities in new knowledge and ideas that are not recognised as valuable by the originating organization. Famous examples of companies developing resources which they did not exploit are Bell and Xerox, private companies that incubated emerging technologies. During the emergence of the semiconductor industry, the growth of knowledge developed at the Bell Labs and the Bell System provided more opportunities for new semiconductor firms than the Bells could exploit (Holbrooke et al. 2000: 1037; cf. Moore and Davis (2004) for a similar situation at Fairchild Semiconductors). The diversity of start-ups based on newly developed knowledge on semiconductor electronics ensured that much of the opportunity space presented by the transistor's invention was explored and exploited. It has been claimed that roughly half the population of Silicon Valley semiconductor manufacturers can be traced back to the Bell Labs (Rogers and Larsen, 1984, 43-45). Another well known source of entrepreneurial opportunities was Xerox Corporation. In the 1960s and 70s managers at Xerox who understood the potential of digital electronics and computing set up Xerox PARC near Stanford University. PARC (its employees aided by Pentagon funding) created many of the key technologies of the PC industry, but failed to take advantage of their opportunities (Smith and Alexander, 2003). Xerox' innovations in computing were largely underexploited because its business model was based on developing copier systems in-house with proprietary standards. PARC employees were alert to business opportunities neglected by Xerox and chose to leave to found new companies based on novel business models (Chesbrough and Rosenbloom, 2002). Large

firms in new technologies are often repositories of unused ideas: big firms have natural diseconomies of scope that a cluster of start-ups does not have (Moore and Davis 2004; cf. Nooteboom 2000).

As regards university based spin-offs, the incidence of this activity has increased considerably in the last decades, not only in the US but also elsewhere (Shahid and Kaora 2007). These companies explore applications of knowledge beyond the academic remit, which established firms find commercially uncertain or which conflict with their current activities (Pavitt 2001). The pioneer in Europe among centres of high tech activity was the University of Cambridge. The first spin-out company from the university was the Cambridge Scientific Instrument Company, founded in 1881 by Horace Darwin, the youngest son of Charles Darwin. The cluster of high tech activities resulted from multi-generational spin out from the university (Garnsey and Heffernan 2005; Library House 2006). [9]

Regions without larger firms at the technological frontier, or sizeable research organisations, will probably have fewer spin-off firms, both because a lack of technically trained people and a shortage of ideas (Moore and Davis 2004). A mix of large and small knowledge based organisations is thus a better starting point for the exploration and exploitation of new ideas than a concentration of small entrepreneurial firms only (Moore and Davis 2004; Rothwell and Dodgson 1994; Nooteboom 1994).

[9] A similar but more large scale process took place at other high-tech clusters like Boston's Route 128 and California's Silicon Valley (Saxenian 1994). A study by BankBoston (1997) revealed that MIT graduates have founded 4,000 currently active companies. Another study suggests that nearly 2,000 of the current San Francisco Bay Area's high tech firms (like HP, Varian Associates, Cisco Systems, Silicon Graphics, Sun Microsystems, Google and Yahoo) were founded by Stanford alumni or faculty (Byers et al. 2000).

Empirical studies on knowledge as a source of entrepreneurial opportunities

How does the creation of new knowledge stimulate high tech enterprise? Two different mechanisms are found to be relevant for high-growth technology-based start-ups: research and human capital (Audretsch et al. 2005; Audretsch and Lehmann 2005b). The latter mechanism involves embodied knowledge flows via highly educated entrepreneurs (Colombo and Delmastro 2002) and the recruitment of students (Mian 1996). Research excellence is a critical factor for high-growth technology based firms. Technical universities are not necessarily more successful in facilitating the spillover and commercialization of knowledge (Audretsch and Lehmann 2005a).[10]

Continued access and absorption of external (scientific) knowledge can also be achieved via the attraction of managers and directors with an academic background. Audretsch and Lehmann (2006) showed – based on board composition of 295 high-technology firms – that there is a strong link between both geographic proximity to research-intensive universities, and board composition, and firm performance. Scientists who act as board members facilitate the access to and absorption of firm-external knowledge (Audretsch and Stephan 1996).

Knowledge rich regions are found to generate more entrepreneurial opportunities than knowledge poor regions (Audretsch et al. 2005; Link and Scott 2005). Even though advances in information technology have increased the access to information, geography still matters. Because

[10] In a study in the 50 largest metropolitan areas in the US Rosenbloom (2007) found a positive effect of the number of science and engineering doctorates on SBIR/STTR grant funds, venture capital investments in a community, and the number of IPOs. Armington and Acs (2001) found that firms are more likely to form in US labor market areas (LMAs) that have a high percentage of college graduates than in those LMAs with high concentrations of less skilled workers.

knowledge is more easily shared through close interaction in local networks, proximity and locality feature prominently in a knowledge economy, with knowledge rich regions operating as centres of new activity. Geographic proximity between nascent entrepreneurs and knowledge sources is very important for the emergence of new firms. For example, Zucker et al. (1994) show that in biotechnology, an industry based almost exclusively on new formal knowledge, the firms tend to cluster together in just a handful of locations. This finding is supported by Audretsch and Stephan (1996) who examine the geographic relationships of scientists working with biotechnology firms. The importance of geographic proximity is clearly shaped by the role played by the scientist, who is more likely to be located in the same region as the firm when the relationship involves the transfer of new economic knowledge (cf. Egeln et al. 2004). Knowledge spillovers are localized and tend to decay rapidly with transmission across geographic space (Audretsch and Feldman 1996; Jaffe et al. 1993). Regions integrate the various agents – individuals, networks, firms, and other organisations – involved in the innovation process in a regional innovation system (Garnsey 1998a; Cooke 2001; Breschi and Lissoni 2001; Asheim and Gertler 2005).

The empirical evidence suggests that entrepreneurs' perceptions of opportunity are affected by their location in a knowledge rich region. This is consistent with the knowledge spillover theory of entrepreneurship, as explained above. Those contexts with greater investment in knowledge experience a higher incidence of knowledge-based entrepreneurship, *ceteris paribus*. However, institutions, capital markets and other factors affect the level of entrepreneurship in knowledge rich regions. Thus it is only recently that knowledge rich regions like Cambridgeshire and the Washington D.C. area

have become centres of enterprise and growth (Garnsey and Heffernan 2005; Feldman and Francis 2003).

The growth of new firms in the knowledge economy has received extensive attention in the literature to which we now turn. The experience of start up is very different from that of growth; that few start-ups reach a substantial size continues to be of interest. Fast growth companies that become major players in their sector are the main job providers among any cohort of new firms (Storey 1997; Davidsson 2005).

Growth of new knowledge based firms

The emerging structure of opportunities in the economy is among the key factors explaining the emergence and growth of firms. However, entrepreneurs and firms differ in ability to absorb and act on perceived opportunities. Beyond knowledge as the source of entrepreneurial opportunities, a matching of opportunities and resources to create value through new activity must take place (Garnsey 1998b; Hugo and Garnsey 2005; Stam and Garnsey 2006).

Ownership of or a license to IP originating in a university can endow the start-up with a unique resource. It has been argued that valuable, rare, inimitable, and non-substitutable resources may endow a firm with a competitive advantage that translate to superior performance (Barney, 1991). This does not automatically lead to a competitive advantage, just as knowledge spillovers cannot be absorbed by all firms. A key element is absorptive capacity: a firm's ability to recognize, value, and assimilate new external

information (Cohen and Levinthal 1989; 1990). The increased absorptive capacity of new firms interacting with academic institutions may provide advantages for developing new products and alliancing with other firms, and ultimately improve the firm's performance. Empirical studies have shown a lack of (direct) positive effects of these university-industry flows on the post-entry performance of knowledge-based firms; an indirect effect via increased absorptive capacity may be more important (Rothaermel and Thursby 2005; Roper et al. 2006). Cockburn and Henderson (1998) demonstrate that firms must exhibit substantial absorptive capacity to capture and appropriate rents from publicly available knowledge.

In order to commercialize technical intellectual property, organizational knowledge is required by the new firm. This latter type of knowledge is the fundamental source of competitive advantage of firms (Grant, 1996). Opportunities must be identified by entrepreneurs and resources must be accessed, secured and mobilised in order to generate returns. Key problems facing the start-up venture must be solved by developing a repertoire of problem-solving skills or competence. As learning is built up to overcome these problems, competences and dynamic capabilities are developed (Hugo and Garnsey 2005). Competences can be viewed as individual and team-based knowledge and skills which yield economic benefit. By accessing, developing, and integrating new and existing knowledge, firms will be able to reconfigure the nature of their resource base, which is necessary to achieve sustainable competitive advantage in a technologically dynamic environment (Teece et al. 1997; Eisenhardt and Martin 2000). The way firm growth is managed affects whether internal resources are developed and successfully matched to opportunities (Penrose 1995; Garnsey 1998b;

Kogut and Zander 1992). In the case of the young knowledge-based firms, the key dynamic capability is the group's ability to detect opportunities for their new technologies and to use their competence to sustain innovation.

In the next section we will present an overview of empirical studies on the determinants of new firm growth, which gives insight into the favourable start-up conditions for the growth of new firms.

Empirical studies on employment growth in new firms

There is continuing interest in identifying the key factors shaping new firm growth, but the answers are elusive. Several empirical studies have sought to examine the determinants of employment growth in new firms using correlation analysis. These studies are summarised in table 1.[11] This table does not give an exhaustive overview of all independent variables ("determinants") analysed in these studies but of those featuring in at least two studies. We have categorized the determinants of the growth in employee numbers in new firms into three sets of factors. Personal level determinants include human capital, social capital, and ambitions of the entrepreneur; firm level determinants include organizational capital and financial capital; variables related to the business environment of the firm are industry or geographical location. Table 1 shows that the outcomes of these studies are scattered: hardly any study takes a similar set of

[11] All these studies address moderate growth in new firms, which creates at most tens of jobs. This is the most common type of firm growth. Those creating hundreds of jobs like firms in the INC.500 (see Bhide 2000; Markman and Gartner 2002) or Europe's 500 lists (see BCG 2002) that create hundreds, in the case of a few, thousands of jobs are the exceptions that alter industries (see Owen 2004).

determinants into account, and when the same determinants are taken into account contrasting outcomes may result.

Consensus is clearest for personal level determinants in table 1, where effects are described in terms of statistical associations. The human capital variables of educational level, start-up experience, industry experience and technical experience have generally been found to be positively associated with firm growth. Positive effects of the entrepreneurial, managerial and technical skills of the entrepreneur on sales growth in new firms were also found by Chandler and Jansen (1992), as was industry experience on sales growth by Siegel et al. (1993). In contrast Stuart and Abetti (1990) found that only entrepreneurial experience (previous new venture involvements) and not managerial and technical experience were important determinants for a composite indicator of new firm growth (based on sales, employment, profits and productivity growth). The transfer of market experience from the parent had a positive effect on the growth of corporate spin-offs according to Tübke and Empson (2002), while the transfer of technical experience was revealed to have a negative effect. Demographic characteristics of founders including gender (female) and belonging to an immigrant group are negatively correlated with firm growth. Social capital measured by such factors as starting a firm with business partner(s) has a consistent positive effect on measures of subsequent firm growth. The motivation at start up to realize an idea or launch an innovation is also positively associated with firm growth.

Table 1 - Empirical studies on employment growth of new firms*

			Cooper et al. 1994	*Vivarelli & Audretsch 1998*	*Bruderl & Preisendorfer 1998*	*Almus & Nerlinger 1999*	*Dahlqvist et al. 2000*	*Schutjens & Wever 2000*	*Bosma et al. 2004*	*Colombo & Grilli 2005*	*Stam et al. 2006*
Personal	**Human capital**	Education level	+		0			0	0	+	0
		Immigrant	-		0		-				
		Self-employed parents	0	0							0
		Management experience	0	+	0			0		0	0
		Unemployment		0			0				
		Self-employment / start-up experience			0		+		0	+	0
		(Long) work experience			-			-	+		
		Industry experience			0			0	+	+	0
		Technical experience				+				+	0
		Male founder	+		+		+		+		+
		Age entrepreneur						0	0	+	-
	Social capital	Entrepreneurial networks			0				+		+
		Emotional support from spouse			0				0		
		Business partners	+		0	0		+		+	0
	Ambitions	Start-up motivation: market need/niche		0			0				

		Start-up motivation: realize innovation		+				0				+		
		Goal: sales growth								0				
		Goal: employment growth									+		+	
		Start-up motive: higher income		+							0			
Firm	**Fin. capital**	Start-up capital	+			+				0			+	0
	Organizational capital	Incorporation				+		+	+	0				
		Start-up size: sales								+				
		Start-up size: employees				0		-		+				+
		Start-up of take-over				-								0
Environment		Industry: retail or personal services	-			0			-	0				
		Industry: manufacturing/construction		+		0				+				
		Industry: business services		0		0				+	0			
		Metropolitan/urban location						0	0 / +	0				-

* see the appendix for an overview of the characteristics of the samples on which these studies are based; '0'= no relation; '+'= positive relation; '-'= negative relation

Among firm level determinants, two factors have a consistent positive correlation: the level of start-up capital and the firm's incorporation. High levels of start-up capital provide the means to invest in resources that enable growth on the longer term, and act as a buffer against external shocks. Being incorporated provides legal status that reduces risks and supports potentially high gains. Research has shown that firms under limited liability are more likely to become insolvent, but also more likely to exhibit high growth (Harhoff et al. 1998). Among business environment determinants, starting in retail/personal services has a negative association with firm growth, while starting in manufacturing or construction seems to have a positive association with growth. This may reflect the minimum efficient size required by different industries or the business cycle in construction.

There is controversy on the effect of work experience and of the initial (employment) size of the firm on growth prospects. On the one hand work experience can provide on the job-learning, leading to valuable knowledge for managing a growing business. However, this depends on type of activity and type of organization in which experience has been gained. Gompers et al. (2005) show that young venture capital backed firms are a fertile breeding grounds for new venture capital backed firms. In these types of organizations, employees learn from their co-workers about what it takes to start a successful new firm and are exposed to a network of suppliers and customers who are used to dealing with start-up companies. Entrepreneurs with lengthy

work experience are likely to become more cautious and conservative than entrepreneurs with shorter work experience.

Inconsistent evidence has been found on the effect of the initial employment size on subsequent firm growth. In the industrial economic literature it is a stylized fact that young and small firms grow relatively fast, because they have to achieve the minimum efficient size (MES) in their industry (Mansfield, 1962; Audretsch et al. 2004). Initial size has been found to have a negative effect on firm growth in these studies (Audretsch et al., 1999; Lotti et al. 2001). Smaller start-ups thus have a higher need to grow (Davidsson, 1991). On the other hand, relatively large start-ups have more human resources at hand to realize growth and are more likely to attract financial capital and human resources, which enables them to grow more rapidly than small start-ups (cf. Westhead and Cowling 1995). These large start-ups may also be more ambitious regarding future growth. There is not much evidence on a discriminating effect of a metropolitan or rural location on new firm growth. There are large international differences between entrepreneurship and firm growth, ambitions as well as realizations, but there is no empirical international comparative research yet on the determinants of employment growth in (new) firms.[12]

In brief, analysis of factors associated with firm growth are dominated by the analysis of variance using cross sectional measures to compare the attributes

[12] See Autio (2005) for one of the few international comparative studies on high-growth entrepreneurship.

or conditions of new firms in samples. Attributes of firms with a successful growth record provide a guide to desirable attributes of new firms. However, inferences from the founding attributes to firm growth are not robust, and are plagued by methodological and conceptual weaknesses. They are unable to trace the feedback effects between dynamic business conditions and the responses of entrepreneurs, employees and managers that underlie firm growth (Garnsey et al. 2006).

Entrepreneurial management

The identification of opportunities is critical for the emergence of new businesses. However, businesses do not grow unless opportunities are realized. This requires firm-building, i.e. the creation of a multi-person organization with a distinctive organizational capability. Long-term growth is determined to a large extent by the interplay of opportunity perception and the ability to realize opportunities (Penrose 1995; Ghoshal et al. 1999).

One of the key assets of new and small firms is their flexibility (Piore and Sabel 1984; Yu 2001). Key elements of the flexibility of firms in general are so-called dynamic capabilities, i.e. "the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments" (Teece et al. 1997, p.516). Dynamic capabilities are the organizational and strategic procedures (referred to as routines) by which

firms achieve new resource combinations (Eisenhardt and Martin 2000, p. 1107). They include the capacity to undertake specific and identifiable processes such as R&D, inter-firm alliancing, new product development, and exporting. With knowledge creation routines (R&D) new knowledge is built within the firm that is of particular strategic relevance in high-tech industries. Alliancing routines bring new resources into the firm from external sources, also often essential in high-tech industries (Powell et al., 1996; Baum et al., 2000; Tapon et al., 2001). With new product development routines the varied skills and backgrounds of firm members are combined to create revenue-producing goods and services. Strategic decision making, for example regarding the entrance into new (international) markets is a dynamic capability in which firm members pool their various business, functional, and personal expertise to make the choices that shape the major strategic moves of the firm.

Quantitative studies such as those cited above have limitations. In particular, they lack a conceptually grounded explanatory model in terms of which to make sense of findings. The authors have proposed one such model, based on Penrosian theory, which explains some of the puzzles associated with stage based models of firm development (Garnsey et al. 2006).

This model differs conceptually from stage models of firm growth. Stages are states or phases which characterize a system (here a firm) at a point in time. In contrast, processes are a related set of events, actions and outcomes that

induce change in a system. There may be several change processes underway at a time and interacting with each other, but system states or phases are consecutive. The developmental processes found among new firms as they mobilize and build capabilities to generate market returns can only be fully illuminated by micro-data from case histories. Companies that go through similar developmental processes because they build similar capabilities in a common sequence may exhibit some measurable evidence of similar phases (e.g. of opportunity search, fund raising, recruitment etc.). This may give the appearance of regular junctures at which growth problems can be said to have been overcome (Vohora et al. 2004). But phases are not universal since new firms differ in the resource endowments they inherit and need different resource bases for different types of output. There is no critical juncture at which sustained growth is assured since young firms that have achieved a period of sustained growth often hit setbacks that, at best, require them to repeat earlier developments. Different types of resource base are built and used in different ways, depending on the activity and business model of the firm (Chesbrough and Rosenbloom 2002). Developmental processes may occur in parallel when firms build capabilities for one product or service while being at an early stage in developing other planned offerings, as in the "soft to hard" strategy of product development funded on early service provision (Bullock 1983).

In brief, we find that while each firm is unique, there are common processes that bring about development and common problems that have to be resolved. Common processes include opportunity recognition and resource matching,

resource mobilization, resource generation and resource accumulation. These make possible the development of competences and capital in a base made up of productive, commercial and financial resources. Problems originating within or outside the firm may deplete this resource base, leading to a turning point in the life course of these firms. These have negative consequences when problems are not solved, but positive consequences when they lead to new solutions and the development of new competence that extend the firm's resource base.

Evidence supporting this model is to be found not only from case evidence but when we examine the unfolding processes through which firm growth takes place. This also throws more light on the constraints and success attributes cited in the quantitative studies on new firm growth. Continuous linear growth is the exception rather than the rule. A study by Garnsey et al. (2006) found that only 6% of the new high tech firms in Cambridgeshire continuously grew over their early life course, while 37% faced severe setbacks (see figure 2).[13]

[13] In a sample of Netherlands start-ups covering all industries and size classes only 0.3 % of the firms reveal a continuous growth path, while 68.6 % had a plateau growth path (Stam et al. 2006).

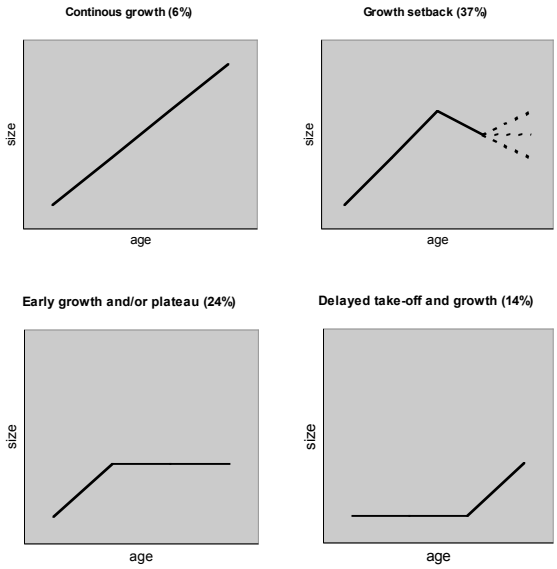

Figure 2. Turning points among Cambridgeshire high tech firms founded in 1990, surviving 10 years (source: Garnsey et al. 2006)[14]

Hugo and Garnsey (2005) showed that the difficulties faced by new firms provide a stimulus to creating technological competence and marketing capability which propel their growth. Initial disadvantages are addressed by mobilizing resources in new ways, by resource economy ('asset parsimony': Hambrick and MacMillan 1984) resource leverage ('bootstrapping': Bhide 2000) and by creating new resources (e.g. 'bricolage': Baker and Nelson 2005). These efforts are linked in a dynamic process of problem-solving that requires strategic relations with others. Resource economy is achieved internally by rearranging the firm's activities and resources in order to produce more with less. New growing firms use their initial resources to gain

[14] This is derived from bi-annual employment data at the firm level, with a threshold of at least 5% change.

further leverage. When faced with a resource deficit that cannot be remedied externally, the firms set out to build their own proprietary resources. Cooperative interactions with other parties, including funders, regulators and suppliers, are used to mobilize resources and open further opportunities. When market solutions proved unavailable, this barrier to the pursuit of the original business idea may be an opportunity to develop a new business idea. A key feature of entrepreneurial responses to adversity is cognitive. Entrepreneurs view the situation they face as a soluble problem which they can address proactively and on which they can have some impact. They reconsider their situation and find ways to turn obstacles to their advantage by re-routing the firm. Recurrent problem solving of this kind enables these new firms to build capability on a cumulative basis. As Penrose (1995) anticipated, to succeed they have to match their resources (in particular the competence they had developed) to shifting opportunities. Information asymmetries, technologies advancing ahead of market provision and government regulation are examples of sources of opportunity. Entrepreneurial opportunities often emerge when leads and lags in market needs and provision create asynchronies between supply and demand and stimulate innovative responses to 'market failure' (cf. Metcalfe, 2004) drive entrepreneurial activity.

Hugo and Garnsey (2005) do not suggest that any and every deficiency can be transformed by entrepreneurial problem-solving into an asset. The cliché that every problem is an opportunity does not recognize that problems can combine in such a way as to close off opportunities and crush motivation.

Undoubtedly early endowments (financial and human capital) are facilitating and attract other favourable attributes in a self-reinforcing process. Timing also plays a large part in securing favourable outcomes for these new firms. But more than good luck is involved in repeatedly identifying and exploiting resources and timely opportunities so as to improve productivity and build capability. Alliancing is essential, but the new firm must have something to offer partners in return. Building competence in response to problems makes it possible to establish useful partnerships that further increase the firms' capability. Not only opportunities but impending threats can be turned to advantage when they spur creative thinking about objectives and new strategic moves. Though most new firms are held back by the continual difficulties besetting growth, those that find their way around these problems grow to be major players in their industry.

A study by Stam and Garnsey (2006) revealed that even in an elite sample of young fast-growing firms, most firms face turning points in their life course. These turning points often constrain growth for a period, and force the firm to focus again after a resource shortage. However, these turning points also enable growth when competence is developed through a problem-solving process. The study showed that there are endemic asynchronies between constituents of the new firm's resource base, input resources and requirements for expansion. This explains why continuous growth is so unlikely. Certain growth mechanisms are more important in certain industries than others. For example, knowledge based service firms require close ties to customers, while for biomedical firms growth is initially realized by

acquiring financial resources from investors (Pisano 2006). However, in the long run the biomedical ventures also have to generate adequate resources from a product market to avoid being taken over or abandoned by their investors.

Entrepreneurial founders do not necessarily have the problem-solving skills required by good entrepreneurial managers. People with the right combination of skills and experience are scarce and the assimilation and motivation of staff can create serious difficulties (Witt 1998; 2000). As the firm grows management information becomes increasingly complex (Greiner 1972). The difficulty for decision-makers in assimilating and making considered judgements increases under conditions of rapid growth. Where reserves have been run down, delays and ill-judged decisions can bring growth to a halt. As new firms grow they face increasing organizational complexity; according to some authors this will require periodic restructuring (Greiner 1972; Romanelli and Tushman 1994; Vohora et al. 2004). Competence based scholars have pointed to benefits of paced growth (Penrose 1995; Hugo and Garnsey 2005; Teece et al. 1997), while organizational ecologists have undertaken studies which show why radical organizational changes impair growth prospects and even survival in young technology based firms (Baron and Hannan 2002; Hannan and Freeman 1984).

How the founders of new technology based firms approach organizational and HR challenges in the early days of building their firms may have enduring effects on the firms (Baron and Hannan 2002, 8-9). This is the issue addressed in several papers based on the Stanford Project on Emerging Companies (SPEC) (see for example Baron et al. 1999; Burton, 2001; Baron et al. 2001; Baron and Hannan 2002). This study found an important determinant of growth of technology based firms to be organizational models or blueprints that entrepreneurs use in launching their new ventures. These blueprints guide entrepreneurs' thinking about how to organize employment and manage personnel. If the origin of the firm is formative for its subsequent development (Hannan and Freeman 1977; 1984), blueprints are likely to be enduring in the life course of new fast-growing firms. Barron and Hannan (2002) showed that changes in organizational blueprints are in general very destabilizing to young technology firms, adversely affecting employee turnover, financial performance, and even survival. These findings suggest that disruption may be considerable when investors replace technical founders who have had a formative role in the company. Selecting people who fitted into the organization and coordination via peer control and, or, culture was more commonly found among firms that achieved an IPO (Barron and Hannan 2002). Selection based on exceptional talent, intrinsic work attachment, and professional standards of coordination, most often found in biotech firms, was common in firms that fared best in the post-IPO phase (Barron and Hannan 2002). These findings demonstrate the importance of dedicated people and a sense of community for the longer-term success of the firm.

Conclusions

This paper has provided an overview of studies about scientific and technological knowledge as a source of business opportunities, and on the emergence and growth of new firms in the knowledge economy. We have shown that new knowledge in science and technology is an important and localized source of entrepreneurial opportunities. Public and corporate sector players do not necessarily commercialize this knowledge because they lack the vision or incentives. New firms arise that seek to do so, but the recognition of emerging opportunities and the mobilization of the necessary resources in order to create new economic value is achieved by only a few. These few high growth start-ups are of higher importance for economic growth than new firms in general. Corporate spin-offs are more likely to turn into these high growth firms than university spin-offs. The international variation in realized firm growth is far greater than the variation in ambitious entrepreneurship, suggesting that entrepreneurs in certain countries face severe constraints preventing their firms from realizing intended growth. The empirical studies on new firm growth showed that high levels of human, social and financial capital are enabling endowments, facilitating the growth of new business. Despite or because of the many problems facing new firms, among the successful innovations that are achieved by dedicated entrepreneurial teams, there are some that have a very major impact on their firm and industry. The fact that these firms more often originate from the US

than any other country can partly be traced back to the huge (direct and indirect) government support to new technology-based firms in the US.

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Appendix – Characteristics of the samples of studies on employment growth in new firms

Authors	*Time period*	*Industries*	*Number of firms*	*Region*
Cooper et al. 1994	1985-1987 (3 years)	Representative for new firm population	1 053	US
Vivarelli & Audretsch 1998	1985-1993 (<9 years; mean age 3 years)	All	100	Emilia (Italy)
Brüderl & Preisendörfer 1998	1985/86-1990 (4 years)	All except crafts, agriculture, physicians, architects, and lawyers	1 710	Munich and Upper Bavaria (Germany)
Almus & Nerlinger 1999	1992/1996-1998	Manufacturing industries (both 'High-Tech Industries' (R&D-intensity above 3.5%) and 'Non-High-Tech Industries' (R&D-intensity below 3.5%).	8 739	Germany
Dahlqvist et al. 2000	1994-1997 (3 years)	All except agriculture, forestry, hunting, fishery, and real estate	6 377	Sweden

Schutjens and Wever 2000	1994-1997 (3 years)	All except agriculture and mining	563	Netherlands
Bosma et al. 2004	1994-1997 (3 years)	All except agriculture and mining	758	Netherlands
Colombo & Grilli 2005	1980 (or later)– 2004 (max. 13 years)	High tech sectors (computers, electronic components, telecommunication equipment, optical, medical, and electronic instruments, biotechnology, pharmaceuticals, advanced materials, robotics, and process automation equipment, multimedia content, software, internet services, and telecommunication services)	506	Italy
Stam et al. 2006	1994-2004 (10 years)	All except agriculture and mining	354	Netherlands