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Finance, Innovation and Emerging Industries – a Review

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Abstract

This paper provides a review entrepreneurial finance in emerging industries. First we examined literature to create a view of industrial emergence with reference to systems thinking. We then explored the role of entrepreneurial finance in emerging industries, and whether it can theoretically slow or accelerate industrial emergence through reference to the literature. We find the link between entrepreneurial finance and industrial emergence is not a simple relationship of more finance generates more innovation and industrial emergence.

Key words: Industrial emergence, entrepreneurial finance, investment, industry evolution

1 Introduction

> 'The financial crash of 2008-9 has been the most damaging economic event since the Great Depression – affecting the lives of hundreds of millions of people.' (Turner, Haldane et al. 2010)

While debates continue on how to avoid a repeat of the most recent financial crash, almost all opinions include the view that investment in some types of innovation offers opportunities for economic growth which can aid economic recovery[1]. In this paper we explore the constituents and dynamics of industrial emergence as a basis from which to examine the role of finance in industrial emergence, with particular emphasis on the financing of new firms. Emerging industries have been defined as:

> '... newly formed or re-formed industries that have been created by technological innovations, shifts in relative cost relationships, emergence of new consumer needs, or other economic and sociological changes that elevate a new product or service to the level of a potentially viable business opportunity.' (Porter Competitive Strategy p.215)

We build on this view of industrial emergence by examining how new ideas come to have a wider economic impact via the firm, and how firms come together to form part of a new, or emerging industry.

Global aggregate data on investment in innovation has shown a decline in recent years raising questions over the impact this will have on innovative capacity. The UK has R&D intensity[2] of less 2%, which is below both the UK government's own target of 2.5% and the EU target of 3% of GDP. Bank lending to SMEs has continued weakening in 2010 and the rate of growth in lending has remained negative in 2011, though credit conditions had improved for larger companies when compared to the previous year (BoE 2010; BoE 2011). Global aggregate data shows a sharp reduction in the amount of venture capital available in addition to an increasing reliance on public funds that now participate in around 42% of deals in the UK (Pierrakis 2010). Seed investment has declined over the last decade, perhaps reflecting poor returns for early stage investments (BVCA 2010). Times to exit, from initial investment to IPO or M&A, have increased across industries, now averaging 7.5 years (Pierrakis 2010). Furthermore comparisons with the U.S. make the performance of European entrepreneurial finance seem inferior with average internal rates of returns (IRRs) comparatively lower (Figure 1). In an increasingly globalised world, investors are likely to move their activities where they can achieve the highest returns, regardless of 'traditional' geographic considerations such as proximity to existing facilities or other investments..

[1] For example the 'sustainability revolution' and the need for cleantech investment to spur on a new growth industry (Stern 2006).

[2] R&D intensity is defined as the % of GDP invested in research and development

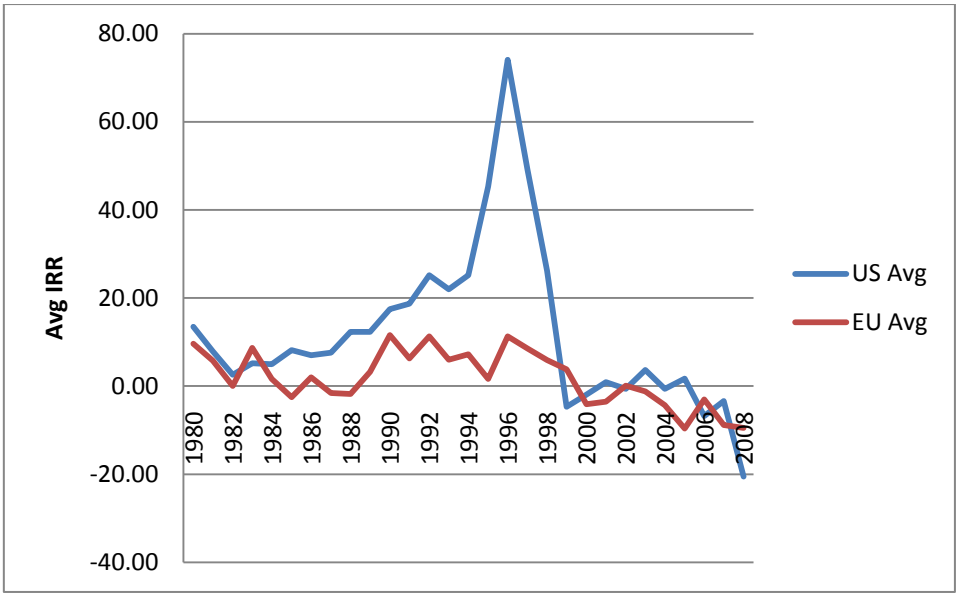

Figure 1 Average fund IRRs according to cumulative year performance (as it is cumulative vintage year performance, figures for 2004 onwards may be incomplete) (Source: Thomson One)

In the wake of financial constraints in public and private spending, understanding how to maximise innovative output with fewer financial resources is of critical importance. Increasingly the case is made for governments to intervene and fill perceived entrepreneurial funding shortages, for example in early stage investments (Reed 2010). In the UK and US, the importance of supporting the emergence of new industries has been identified as a key component in economic recovery (NAP 2007; Turner, Haldane et al. 2010). But will support for entrepreneurial finance also help support the emergence of new industries? We explore the mechanics of industrial change to examine the contribution of finance towards industry creation. Of concern is the ability to direct investment to firms and industries with the most potential for growth and positive impact on the economy. This paper sets out the main schools of literature to inform whether industry emergence can in theory be accelerated or slowed depending on the amount and type of finance available. It begins with a brief overview of industrial dynamics, followed by an exploration of the processes leading to industrial change. This leads to a closer inspection of the role of finance on the emergence of industries.

2 Industrial emergence

Although innovation has often been categorised as a one-way linear flow from R&D to new products, studies have shown the process of innovation to be less structured and to involve multiple interactions and networks (Freeman 1992; Malecki 2000; Foxon, Gross et al. 2005). While the linear model has theoretical elegance the majority of studies suggest more dynamic and complex processes involved in innovation and industrial emergence.

2.1 Knowledge and innovation

Information and knowledge tend to share features with public goods i.e. more than one person can hold an idea or repeat it (unless patented or copyrighted). The science base has

typically been associated with the generation of new knowledge. Historically much science was viewed as 'publicly supported scientific commons' (Nelson, 2004 p.455) readily available for further exploration and exploitation. While much of the knowledge residing within the science base used to spillover into the business environment, research is increasingly privately funded, and many Universities have introduced formal technology transfer offices. With progressively more privatisation of the 'scientific commons' questions arise regarding how this impacts the evolution of industries (Dosi, Llerena et al. 2006).

While science is often viewed as a predecessor to technology and its application within a commercial setting, at times practical inventions have arisen before the scientific understanding of why they worked (e.g. steam engine, airplane)(Dosi, Llerena et al. 2006). Technological advances can be essential to scientific advances, for example in instrumentation. Typically there is interaction between science and technology which can advance both. However it has been suggested that since the industrial revolution, the relative contribution of science to technology has been increasing and its impact has become more and more pervasive (Perez 2004; Dosi, Llerena et al. 2006). Companies increasingly source knowledge from a variety of sources at home and abroad (Figure 2). For example recent studies show the importance of 'soft companies'[3] as intermediaries, collaborators and originators of new knowledge (Connell and Probert 2010).

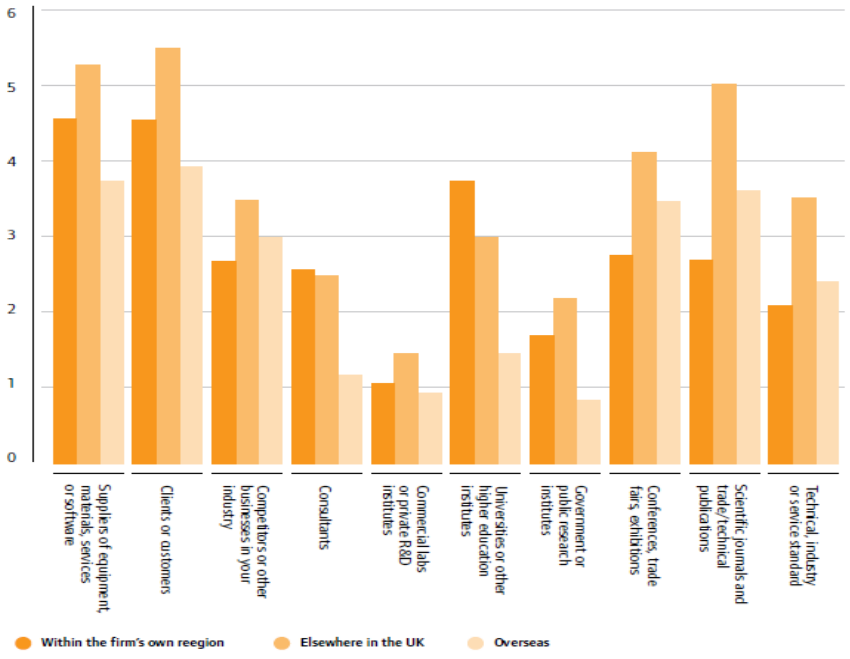

Figure 2 Frequency of knowledge sourcing by types of external sources and their locations (Huggins, Izushi et al. 2010) p.14

Measuring the contribution of science to innovation and emerging industries remains challenging. Aggregate data indicates a slight fall in UK R&D intensity over the last ten years

[3] The authors define a soft company as a science or technology based company whose business model is to provide R&D based services (e.g. technical consulting, contract R&D) and which draws on its expertise and/or proprietary technologies to provide bespoke offerings for a range of customers and applications.

(Figure 3). This aggregate number includes a variety of R&D instruments, including public sector contracts. The link between R&D intensity and innovative output is not direct, though perhaps indicative as suggested by the UK innovation scorecard (Figure 4). Innovation scorecards include other factors in addition to R&D spend (InnoMetrics 2011). But country wide data masks industry or regional specific activities. In the UK a recent report suggests public sector contracts have not typically been awarded to ventures associated with a high proportion of breakthrough or radical innovations especially when compared to the U.S. (Connell and Probert 2010). Other studies indicate a positive correlation with R&D spend and economic performance of a country (Marrano, Haskel et al. 2007; Lane 2008), but only up to 1.5% as a proportion of GDP (Gill, Minshall et al. 2007). High corporate R&D spend as a percentage of sales are typically associated with high technology industries such as pharmaceuticals and biotechnology (Figure 4).

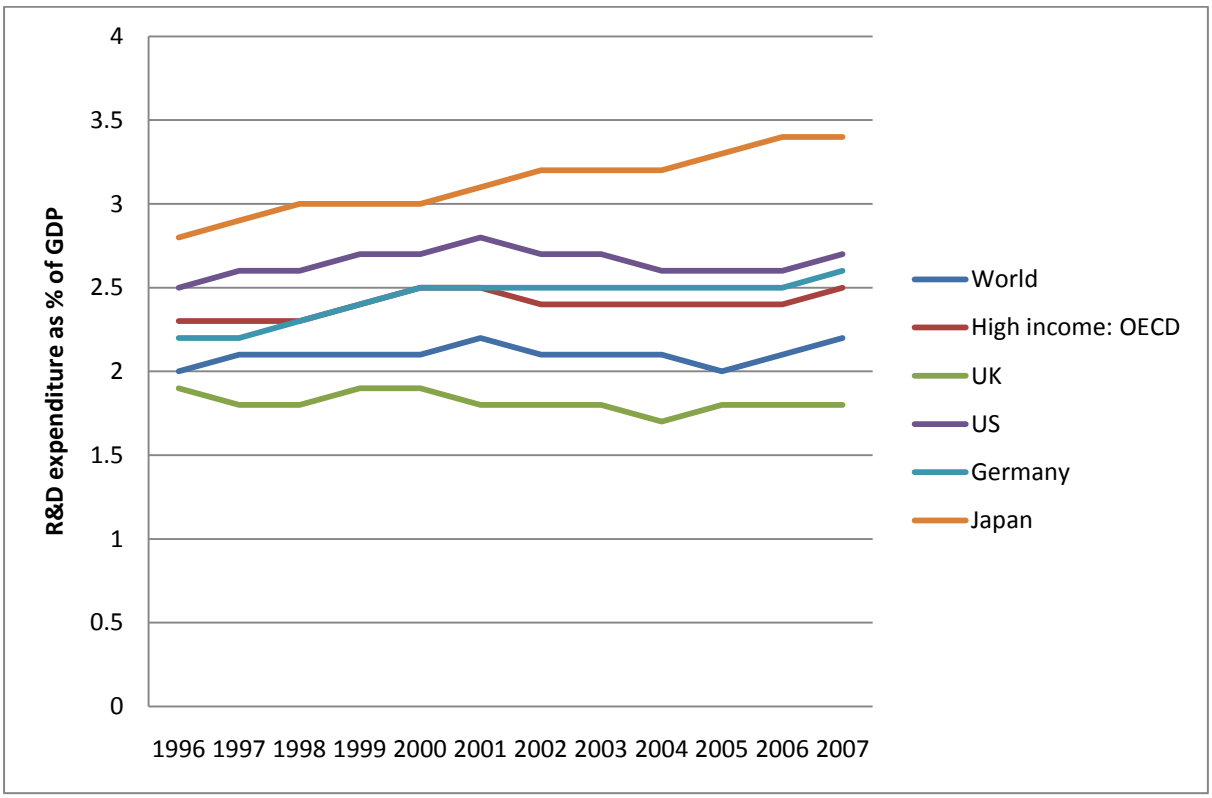

Figure 3 R&D intensity (Source: World Bank[4])

[4] http://data.worldbank.org/

Rank 2010	R&D in 2009 (£m)	Change in R&D over last year (%)	R&D as % of capex (%)	Change in employees over last year (%)	Change in sales over last year (%)	Change in profits over last year (%)
Pharmaceuticals & biotechnology	8,922	0.9	321%	-2.2	11.1	14.1
Aerospace & defence	1,643	-5.0	127%	1.4	14.8	-14.9
Software & computer services	1,621	8.6	281%	-1.5	0.2	-18.2
Automobiles & parts	1,529	9.1	157%	-5.3	-7.6	-152.4
Banks	1,390	-7.0	16%	1.3	44.8	n/a
Oil & gas producers	1,119	-7.3	3%	-5.7	-36.0	-45.3
Technology hardware & equipment	1,067	2.1	278%	-2.0	-0.7	-59.4
Food producers	1,034	-3.4	40%	-4.5	-1.0	8.2
Fixed-line telecommunications	1,031	-8.0	55%	-8.1	-2.7	512.7
Electronic & electrical equipment	647	1.4	254%	-5.4	2.6	-31.2
Total*	25,262					

* Including all other sectors.

Figure 4 UK Innovation Scorecard 2010 (BIS 2011)

So while science can contribute knowledge which opens up potential opportunities for new technological trajectories, knowledge is used in a variety of ways:

> '...inventions can occur at any time, with different importance and at varying rhythms. Not all of them become innovations and not all innovations diffuse widely. In fact, the world of the technically feasible is always much greater than that of the economically profitable, and this, in turn, is much greater than that of the socially acceptable.' (Perez 2004) p.219

As this study focuses on the commercial development of innovation, it is suggested that factors influencing the emergence of an industry occur predominantly outside the science base assuming a certain threshold of activity is achieved. Knowledge does not create economic value by itself, but rather has the potential of economic value creation if it is absorbed and developed by firms (Hussler, Picard et al. 2010).

2.2 Firms

Typically there are long lags between original 'discoveries' and their useful commercial applications due to the nature of technology:

> 'most technology is specific, complex....[and] cumulative in its development... It is specific to firms where most technological activity is carried out, and it is specific to products and processes, since most of the expenditure is not on research, but on development and production engineering, after which knowledge is also accumulated through experience in production and use on what has come to be known as "learning-by-doing" and "learning-by-using"' (Pavitt, 1987 p.9 cited in Dosi et al. 2006 p.1451)

While the bulk of innovations are carried out by existing firms, these tend to be incremental and focused on lowering costs and raising performance within existing business opportunities (Christensen 1997). Existing firms are often associated with competence enhancing innovations which add value to existing expertise (Tushman and Anderson 1986; Christensen

1997). The emergence of new industries is however associated with a suite of radical and competence destroying innovations and new entrants (Utterback 1994; Freeman and Louca 2002).

While much work has focused on improving the ability of established firms to introduce radical innovations, new entrants and smaller firms continue to have features which make them suitable for the introduction of radical innovations and the emergence of industries. They tend to be fast movers and learners and so able to respond quickly to changing opportunities, as occurs during turbulent and uncertain periods of industrial emergence. Corporations try to gain these benefits through Corporate Venturing which focuses on the creation of new businesses within or outside the corporate organisation (Narayanan, Yang et al. 2009). Industries frequently emerge in niches largely ignored by established industry, where early feedback on new products and services can be obtained while avoiding the need for capital intensive activities associated with mass production (Chandler 1990).

Not all new firms are associated with high growth. A recent study indicates fast-growing new firms tend to originate from a rise in the proportion of employment of scientists and engineers versus employment in sales and production in industries (Eckhardt and Shane 2010). High growth[5] firms are reported to represent just 6 per cent of all UK firms employing ten or more people (Anyadike-Danes, Bonner et al. 2009). The majority (80%) of high-growth firms employed fewer than 50 people, and firms under five years old were responsible for a fifth of the increase in employment (Anyadike-Danes, Bonner et al. 2009). A study at the cluster level also showed the disproportionate impact on employment in the cluster as a result of high growth firms (Garnsey and Mohr 2010)[6]. Few firms become high growth immediately after inception, and most experience irregular growth paths making predicting which firms become high growth challenging (Heffernan and Garnsey 2002; Acs, Parsons et al. 2008). Nonetheless new firms are associated with a variety of generating processes (Stam and Garnsey 2005) that are an essential part of change, as identified in evolutionary studies (Metcalfe 1998).

While it is recognised that a variety of firms contribute towards the emergence of an industry, entrepreneurial endeavour and high growth firms are key dynamic elements which prompt wider changes of the kind that can lead to industrial emergence. We focus this study on firms with potential for high growth. How firms perform the translational task of commercialising technology is now discussed.

[5] The report defines 'high-growth' as a 20% increase in employment in any one year. Gazelles are those less than 5 years old.
[6] Firm growth contributed two thirds of all new job creation in the Cambridge tech cluster between 1988-2008 versus entries and exits that contributed a third. (Garnsey and Mohr 2010)

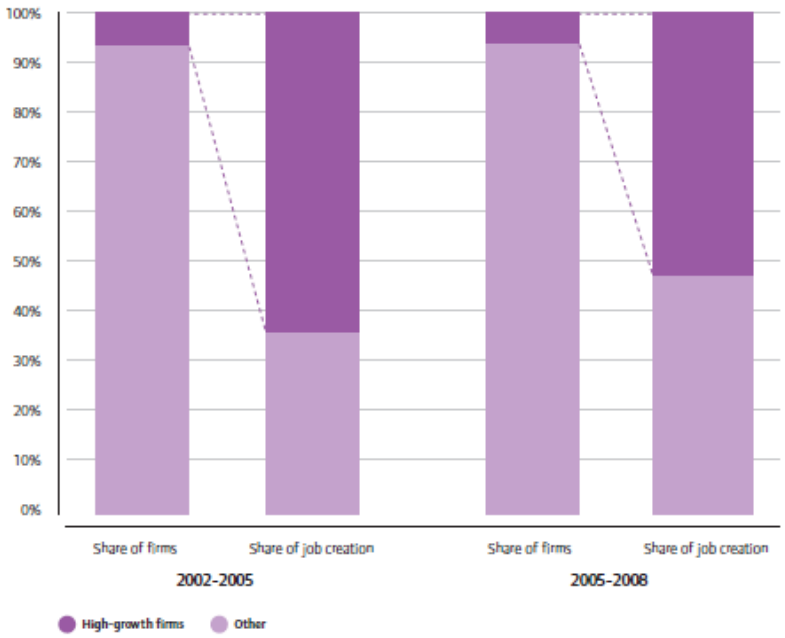

Figure 5 The contribution of high-growth firms to job creation (10+ employees) (Anyadike-Danes, Bonner et al. 2009) p.4 (Original source: ONS Business Structure Database)

2.2.1 Innovation as an entrepreneurial matching process

For successful diffusion in the market, technological innovation consists of a matching process between technological capabilities and market opportunities (Freeman 1982 p.109). This matching process includes 'learning by doing' and 'learning by using' (Foxon, Gross et al. 2005). The entrepreneurial process is fundamental to technological change, and yet is sometimes treated as a 'black box' in the innovation management literature (Jaffe, Newell et al. 2001). Yet it is this entrepreneurial process within either an existing or new firm which builds a commercial structure around an innovation with the aim of creating and capturing value. By definition an innovation is distinct from an invention through its link to productive opportunity:

> 'The productive activities of such a firm are governed by what we shall call its 'productive opportunity', which comprises all of the productive possibilities that its 'entrepreneurs' see and can take advantage of.' (Penrose 1995) p.31

The innovation is then a resource which may allow a firm to take advantage of a productive opportunity, depending on how it is developed and used:

> 'Strictly speaking, it is never resources themselves that are the 'inputs' in the production process, but only the services that the resources can render. The services yielded by resources are a function of the way in which they are used – exactly the same resource when used for different purposes or in different ways and in combination with different types or amounts of other resources provides a different service or set of services.' (Penrose 1995) p.25

For example it has been shown that entrepreneurs do not discover the same opportunities in response to a given technological change (e.g. a new intellectual property right) since these perceived opportunities are shaped by idiosyncratic information and other resources[7] specific to the entrepreneur (Shane 2000)[8].

The idea of 'opportunity' has attracted academic interest, with particular emphasis on 'entrepreneurial opportunity' (Ardichvili, Cardozo et al. 2003; Eckhardt and Shane 2003). Shane and Venkataraman (2000) posit that the recognition of entrepreneurial opportunities is a subjective process, but that opportunities themselves are objective phenomena that are not known to all parties at all times. They specify the entrepreneurial element:

> 'Entrepreneurial opportunities differ from the larger set of all opportunities for profit, particularly opportunities to enhance the efficiency of existing goods, services, raw materials, and organizing methods, because the former require the discovery of new means-ends relationships whereas the latter involve optimisation within existing means-ends frameworks (Kirzner, 1997)' (Shane and Venkataraman 2000 p.220)

There has been disagreement in the literature as to whether opportunities are created or discovered (Dutta and Crossan 2005). By viewing the entrepreneurial opportunity as a developmental process, contrasting definitions of the phenomena can start to be resolved. If the entrepreneurial opportunity is conceptualised as 'market needs, unemployed/underemployed resources' then the entrepreneurial developmental process is trivialised (Dee 2008). Contrastingly, if the entrepreneurial opportunity is conceptualised as something that can support a successful enterprise, the developmental process is emphasised (Ardichvili, Cardozo et al. 2003). This is because the entrepreneurial process of developing an opportunity occurs between the identification of market needs and unemployed/ underemployed resources and the successful enterprise (Figure 6).

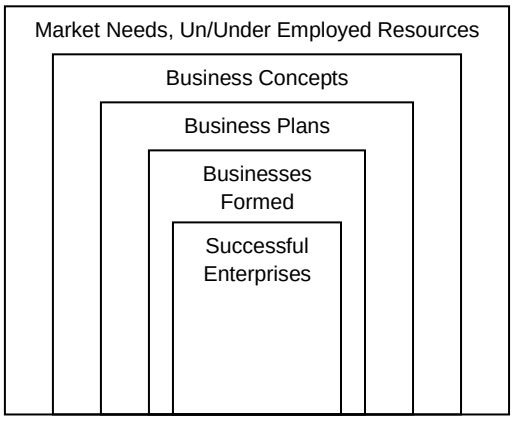

Figure 6 From a market need to a successful enterprise (Ardichvili et al*. 2003 p.112)*

For an opportunity to be entrepreneurial it is suggested that it must be linked to expectations of value creation and capture, and therefore the emergence of a successful enterprise

[7] Finance is an example of a resource which could constrain or enable a particular strategy to secure a productive opportunity.
[8] In this study, entrepreneurs perceived different business opportunities from exploiting the same MIT invention.

(Garnsey 2005). Value creation and capture depend not only on the activities of the firm, but also its relationship to the business environment (e.g. competitors, complementary technologies, regulations, customers etc.). We therefore emphasise the importance of the entrepreneurial process within entrepreneurial opportunities for understanding the link between innovation and the wider business environment.

2.3 Industry and institutional infrastructure

An innovation alone does not create a new industry. Rather it is a constellation of innovations that are part of 'systemic changes in the logic of the co-ordination process of the large and interrelated techno-economic or socio-institutional systems' that contribute towards an evolving structure (Freeman and Louca 2002) p.41. Industries emerge as part of this evolving structure and depend not just on an accumulation of firms acting on related entrepreneurial opportunities, but also the emergence of industry and institutional structures (Van de Ven 1993; Aldrich and Fiol 1994).

In practice the emergence of an industry remains difficult to identify and assign to a particular time period, particularly as:

> '…boundaries of industry begin to blur as substitute products are developed in other industries, and as technologies fuse together to form new products and product categories' (Bettis and Hitt, 1995)

Building an industry can be just as important for an organisation as building its own organisation. While this may seem counterintuitive, since a thriving industry brings competition, it is often recognised by pioneer firms as instrumental to industry growth (Dee 2008). In an industry's formative years:

> 'From an institutional and ecological perspective, founders of new ventures [in new industries] appear to be fools, for they are navigating, at best, in an institutional vacuum of indifferent munificence and, at worst, in a hostile environment impervious to individual action, in addition to the normal pressures facing any new organisations, they also must carve out a new market, raise capital from sceptical sources, recruit untrained employees, and cope with other difficulties stemming from their nascent status.' (Aldrich and Fiol 1994) p.645

The risk of 'pioneer burnout' in new industries suggests pioneers bear the costs of advertising but the benefits of advertising can be appropriated by other founders entering the market later (Mowery and Rosenberg 1998; Rao 2004). Industries, like firms, may emerge but this does not secure an inevitable life-cycle where they mature and thrive. Industries may fail shortly after emergence, or stagnate within a niche market.

The emergence of institutional structures requires institutional activists to campaign and convince others of their view as:

> 'A new industry becomes taken for granted only when actors do not question the value of the industry, do not have doubts about the usefulness of the radical new

product underlying the industry and do not even think of alternatives' (Zucker, 1983)(Rao 2004) p.360

Van de Van's components of community infrastructure for innovation vary between industries and geographies but show the many factors which institutional activists can influence.

Components of community infrastructure for innovation
Institutional arrangements
- Legitimation (creation of trust)
- Governance (norms, rules, regulations, laws)
- Technology standards
Resource endowments
- Scientific/technological research
- Financing and insurance arrangements
- Human competence pool (training and accreditation)
Proprietary functions
- Technological development functions: R&D, testing, manufacturing, marketing
- Innovation network/resource channel activities: appropriation of common goods (science, finance, labour) vendor-supplier-distributor channels
- Market creation and consumer demand

Figure 7 A social system framework for understanding innovation development and industry emergence (Van de Ven 1993) p.341

Industrial emergence will be impacted by the infrastructure for innovation specific to each industry, location and time. Cultural differences affect the approach and acceptability of different styles of government. Government influences the structure of appropriability regimes, markets, legal and tax structures etc., which are all of concern to investors (Spencer, Murtha et al. 2005).

A country's specific cultural, legal and regulatory environment impacts incentives and costs to innovation and entrepreneurial finance (Hall 2005). For example, appropriability regimes not only vary between countries but also influence the perception of achievable returns from innovation. The premise that private gains from innovation are necessary for entrepreneurs and business firms to undertake expensive and time consuming search and development of innovation is accepted as a feature of modern capitalism (Dosi, Marengo et al. 2006). However appropriability can be achieved in a variety of ways by securing inimitable knowledge and/or know how in different domains (Teece 1986; Teece 2006). Appropriability extends far beyond legal appropriation mechanisms like copyrighting and intellectual property rights. However the full range of mechanisms of appropriability are not all measurable and as such innovation is often associated with patenting as it is readily identifiable and publicly recorded.

Intellectual property regimes vary between countries and industries, and evolve over time. Often stronger intellectual property regimes are assumed to lead to a higher rate of investment in innovation resulting in more innovation. However this assumption is challenged by research suggesting it is at best a second order effect, and at worst a hindrance to innovation when too strong a regime is enforced (Levin, Klevorick et al. 1987; Dosi,

Marengo et al. 2006). For example the software industry emerged under a weak IP regime, the transistor was also liberally licensed, yet both experienced rapid innovation and growth (Dosi, Marengo et al. 2006). It is also possible that different strengths in IP regime and appropriability are relevant at different stages in the industry life cycle. Once again we are reminded that securing a patent does not secure a business. It is rather the entrepreneurial process which depends on the people and resources within a firm in conjunction with features of an emerging business environment that determine how an idea is developed and ultimately commercialised.

While it seems evident that the institutional structure surrounding an industry may affect the scope and scale of its emergence, this too unfolds over time. Whether the location of an emerging industry is dependent on favourable institutional structures specific to that industry remains uncertain. For example work on clusters indicates an industry can emerge quite unexpectedly in an area as a result of the location of one 'exemplary' firm (Klepper 2010). With increasing globalisation, the emergence of industry may not be restricted by a particular country's regime, but instead move so that a science base in one country may lead to the emergence of an industry in another. As people and companies become more mobile, and as funding for R&D originates progressively more from international sources, questions are raised about the efficacy of public support for innovation which may be commercialised elsewhere (Bloom and Griffith 2001).

This brief view of the system of innovation positions industry emergence within a much broader spectrum of activities. This review has emphasised the complex process which contributes to the emergence of industries, and the need for a multi-level analysis (Phaal, O'Sullivan et al. 2010). While new and established firms are identified as important, new ventures have been identified as a disproportionately important variety generating mechanism. We now discuss the dynamics of industrial emergence and change.

3 Industrial dynamics

Studying change at the industry level presents theoretical and empirical challenges (Forbes and Kirsch 2010). These challenges relate to complexity and boundary problems associated with an industry level analysis, further complicated when trying to identify the emergence of an industry which adds temporal uncertainty as to its beginning and end. Perhaps reflecting these difficulties it has been estimated that fewer than 10% of entrepreneurship articles published over the last two decades focus on the industry level of analysis (Chandler and Lyon, 2001 in Forbes).

There are broadly two relevant streams of research: industry life cycle dynamics which focuses on market structure and the entry, growth and decline of firms; and industry evolution which encompasses a broader view including the nature of knowledge and institutional change (Malerba 2007). Several studies converge on the view that a life cycle starts with a radical innovation through the entry of new producers, followed by demand growth, a greater emphasis on process innovations and a selection process from which emerges a concentrated market structure (Utterback and Suarez 1993; Utterback and Allan 2000). This model appears to apply most appropriately to manufacturing settings where

dominant designs emerge. As an industry emerges, firms tend to focus on product innovation and matching this to customer needs. As an industry matures process innovation is critical as firms compete on price (Utterback 1994). Recent work suggests some industries then move into an additional phase of service innovations (Cusumano, Kahl et al. 2006).

This 'systems'[9] approach extends beyond the role of firms as industries change to include other factors in the business environment such as institutional change. Historical studies have revealed the importance of 'systems of innovation', for example complex supply networks and complementary innovations in the emergence of electric power, railway and telecommunications systems (Mowery and Rosenberg 1998; Nairn 2002). Work on systems of innovation overlaps with long wave research (Freeman and Louca 2002; Perez 2004), and includes evolutionary models of industrial change. Empirical evidence for industry evolution and life-cycles has been derived from analyzing industrial dynamics of innovation (e.g. number of firms, market concentration, etc.) in addition to econometric approaches (& cliometrics), and 'history friendly models' (Malerba 2007). Such empirical evidence supports a heuristic model[10] of paradigmatic shifts characterised by different phases: the laboratory invention phase; decisive demonstrations of technical and commercial feasibility; explosive take off and growth during a turbulent phase of structural crisis in the economy and politically; continued high growth with system now accepted as common sense; slow-down and erosion of profitability as the system matures and is challenged by newer technologies; maturity and decline, with some 'renaissance' effects from new technologies (Freeman and Louca 2002).

While new industries represent an important context in which firms and nations compete, it has been suggested that more work is needed to better understand the unfolding of key processes in emerging industries across a range of actors (Forbes and Kirsch 2010). Evolutionary models recognise variety generation and selection as interactive processes which determine the propagation of patterns of industrial activity (Nelson and Winter 1982; Nelson 1995). However disagreements remain, for example regarding appropriate units of selection. Feedback mechanisms such as dynamic increasing returns can cause unexpected outcomes, for example when:

- *The technology is cumulative* (Nelson 1995). When there are several plausible technologies, inventors may focus on one or develop a breakthrough by chance. This chance event results in a perceived gap in performance capabilities between the plausible technologies.
- *Network externalities* (David 1993). When a technology demands consumer learning for its operation, the technology can become locked-in. For example: the QWERTY keyboard, despite arguments for ergonomic inefficiency, has become the dominant design for keyboards since it depends on consumer learning for efficient use.

[9] Since the 1970s much of the work from the Science Policy Research Unit at the University of Sussex has greatly contributed to work on systems of innovation and industry evolution. This group has included Christopher Freeman, Giovanni Dosi, Richard Nelson, Luc Soete, Keith Pavitt, Carolota Perez. It is now called the Science and Technology Policy Research.

[10] 'It is full of exceptions and of huge independent events that constantly twist and break the proposed regularity.' (Perez p.49 Tech and finance).

- *Requirement of complementary technologies* (Nelson 1995; Kemp and Schot 1998). The gasoline internal combustion engine required a road and fuelling infrastructure as well as mechanics trained to deal with automobile problems in order to run.

It is perhaps not surprising that complexity including unanticipated consequences and feedback effects lead to uncertainty.

Both evolutionary and industrial life cycle approaches link industry emergence with high levels of uncertainty:

> 'Early in the history of an industry – when knowledge is changing very rapidly, uncertainty is very high, and barriers to entry very low – new firms are the major innovators and are the key elements in industrial dynamics.' (Malerba 2006) p.383

The link between risk and uncertainty has been debated, particularly as uncertainty may introduce a randomness to economic modelling (Davidson 1991)[11]. Knight famously distinguished risk from uncertainty by stating that a probability of outcomes could be assigned to risk, but not to uncertainty[12]. Or as Keynes described:

> "By 'uncertain' knowledge, let me explain, I do not mean merely to distinguish what is known for certain from what is only probable. The game of roulette is not subject, in this sense, to uncertainty...The sense in which I am using the term is that in which the prospect of a European war is uncertain, or the price of copper and the rate of interest twenty years hence...About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know." (J.M. Keynes, 1937)

Early in the stages of industry emergence this type of uncertainty seems particularly evident, and is associated with technology, market, regulatory and institutional uncertainty[13] (Aldrich and Fiol 1994; Freeman and Louca 2002; Malerba 2006). However the range of outcomes possible from conditions of uncertainty are likely to be tempered by path dependencies (i.e. history matters) within the business environment (David 1993; Nelson 1995).

Industries are an important context in which firms and nations compete and which present different challenges and opportunities depending on their phase of evolution, geography and specific industry characteristics (Freeman and Louca 2002; Forbes and Kirsch 2010). How long industry emergence occurs is a subject of debate, but it is considered 'one temporal component, or interval, within an "industry life cycle" model of how industries evolve over time' (McGahan *et al.* 2004 in Forbes p.3).

[11] http://homepage.newschool.edu/het//essays/uncert/intrisk.htm
[12] Whether in real life you can ever ascertain the 'odds' or probability of different outcomes has been much discussed e.g. Taleb (2008).
[13] This uncertainty is connected to a need for variety generation to avoid premature lock-in of a solution that will lead to an inferior technology stream of industrial emergence

Having explored the main constituents and dynamics of industrial emergence, we investigate the role of finance and how it may impact the emergence of industries. We do this with a view that emerging industries are characterised by highly uncertain business environments.

4 Emerging Industries and their relationship with Investment

This section explores theoretical contributions towards understanding the role of finance for new ventures and emerging industries. As has already been discussed, this involves consideration of a large complex system involving a multitude of actors/units across multiple levels of analysis. We will therefore focus on key levers of industrial emergence as identified from the previous sections. We will structure this around three main areas. Concerns regarding private under-investment in innovation have been related to lack of incentives to invest (imperfect markets for knowledge) and the lack of means to invest (imperfect capital markets) from a market failure perspective with an investor-centric approach (Peneder 2008). This approach relates well to policy which tends to take a market failure perspective and as a result offer 'market corrections' to enhance investment incentives and stimulate the capital markets (Gill, Minshall et al. 2007; Peneder 2008). We explore both of these investor-centric perspectives in addition to firm incentives to seek external sources of finance.

4.1 Incentives to seek external sources of finance

Prior to securing revenue from a perceived entrepreneurial opportunity, research and development (R&D) is often required. Finance is a flexible resource which offers the means of acquiring other necessary resources during the R&D process. R&D can be funded through a variety of financial instruments, from the firm's own financial resources, to grants, debt and equity finance. From the firm perspective, a 'pecking order' has been recognised when it comes to preferences of finance (Casson, Martin et al. 2008). This pecking order relates to the idea that firms' owners will try and use the least amount of effort to raise sources of finance, and links to information asymmetries and control rights (Myers and Majluf 1984). This suggests firms prefer using grants first, then internal funds (e.g. from cash flow or personal finance), followed by debt finance and last by equity finance.

New firms can alleviate the need for external sources of finance through access to early revenue streams or delaying the venture creation process if research and development can continue in another organisation e.g. corporation, university, technology consultancy. It has been suggested that governments have focused too much on the inputs of research and development and finance to the entrepreneurial process, and not enough on value creation and capture through 'venturesome' customers (Bhide 2006). One such customer for new ventures may be the public sector. However, while the U.S. government is a valued customer to many SMEs and a critical first customer for many ventures through the Small Business Innovation Research (SBIR) programme[14], there have been problems emulating the scheme in the UK (Connell 2006). In the absence of sufficient revenue from sales, the high growth firm usually seeks external sources of finance.

[14] http://www.sbir.gov/

A variety of grants is available for new firms and new projects to undertake market research, R&D and expansion. These are often a favoured source of finance as they provide a non-repayable lump sum[15]. A UK survey of grant applicants suggests[16] many projects would not have been undertaken without being awarded a grant (Figure 8) (PACEC 2009).

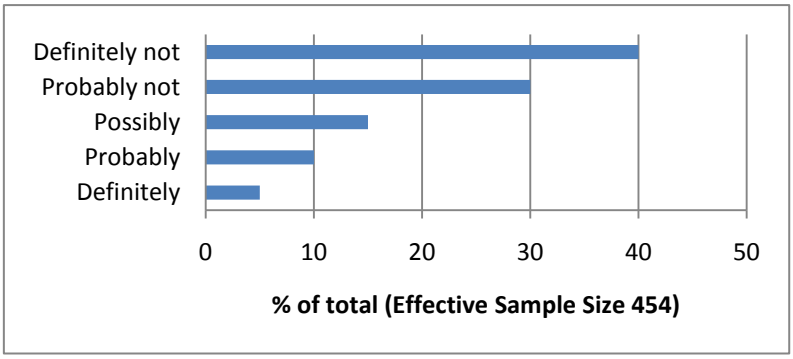

Figure 8 Would your project have gone ahead if you had not received an award? (PACEC 2009)

While broadly empirical evidence supports the pecking order theory[17], there remain questions about whether it relates to highly innovative and high growth firms (Peneder 2008). For high growth firms, empirical evidence suggests a reversal of the 'pecking order' with a higher reliance on equity finance than would otherwise be expected (Peneder 2008). Even when grants are available, these are rarely sufficient to fund high growth. The structure of the UK banking sector is generally regarded as inappropriate for widespread provision of debt financing for smaller firms owing to problems assessing and monitoring their progress (HMTreasury and BIS 2010). Further problems securing debt finance are attributed to a limited ownership of tangible assets coupled with uncertainties of cashflow in new firms (Cowling and Murray 2010). The availability of bank finance also fluctuates depending on the state of the economy and changing industry standards (Figure 9). This has caused the perception of a financing gap that affects high growth firms, 'a limited number of firms, but it is precisely these companies that bear the highest potential to drive economic development through radical innovations' (Peneder 2008) p.522.

[15] The main cost to firms is in the search and application process for the grants, which if excessive can negate the benefits of a grant. Compliance costs are also non-trivial as failure to demonstrate adherence to the terms of the grant may result in a demand for repayment.

[16] It is likely that many survey respondents would want to encourage continued public support of grants which might have led to an exaggerated figure.

[17] 64% of companies that expected to grow in the coming years stated that they would prefer to apply for a bank loan rather than seek equity funding (p.9 Gallup Organisation 2009)

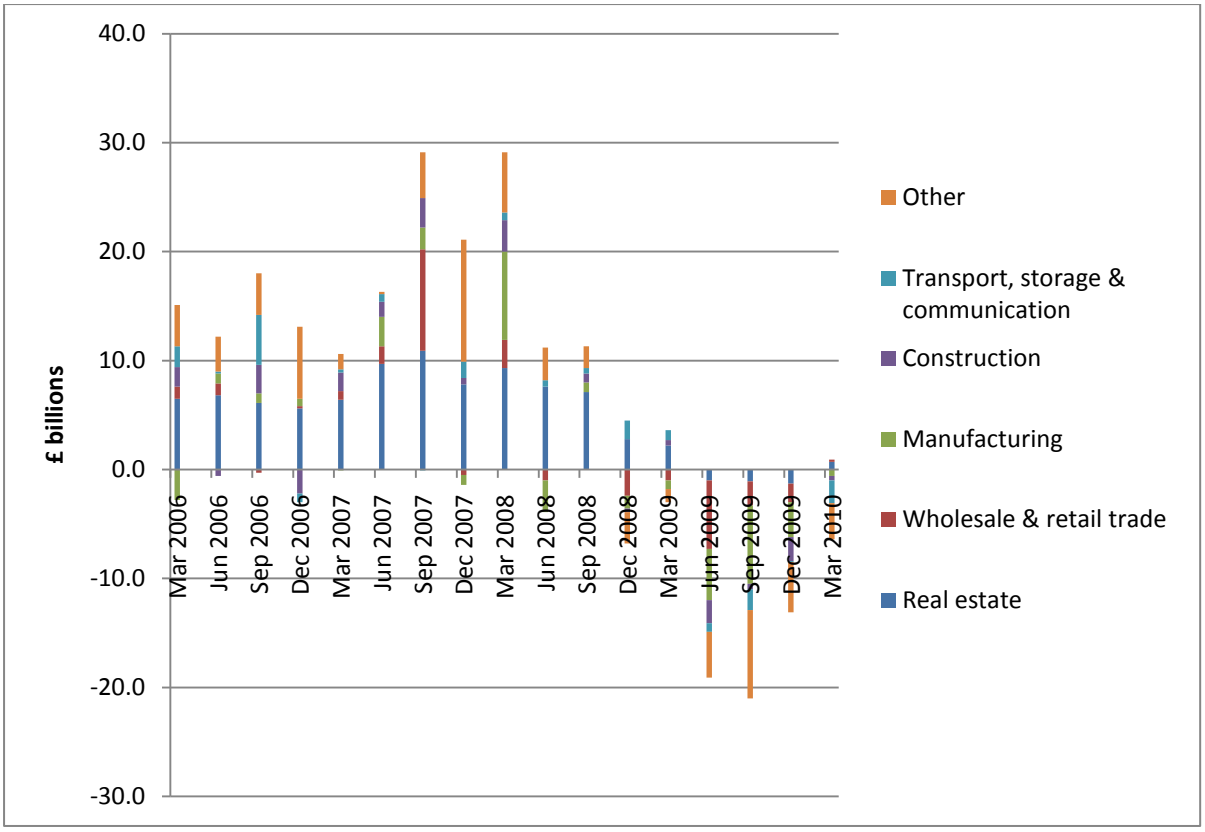

Figure 9 Lending to UK businesses – sectoral breakdown of quarterly net lending flows by UK Monetary Financial Institutions (MFIs) (Source: Bank of England[18])

Equity financing mainly refers to business angel finance and venture capital finance, both of which arose out of the particular financing needs of high growth, high perceived risk ventures (O'Sullivan 2006). Few enterprises are high-growth with venture capital funding just 0.01% of nascent entrepreneurs (Reynolds, Bygrave et al. 2003). Corporate Venture Capital (CVC) has modelled itself on venture capital and offers another source of finance for ventures. Business angel investment has become more organised and recognised as a key source of finance for entrepreneurs over the last twenty years, especially earlier stage investments (Mason and Harrison 2010) (Figure 10 & Figure 11). Venture capitalists and business angels increasingly offer some debt finance in addition to equity finance (Denis 2004). These sources of finance are structured according to different risk/reward profiles associated with varying stages of product development and commercialisation (Figure 12).

[18] www.bankofengland.co.uk

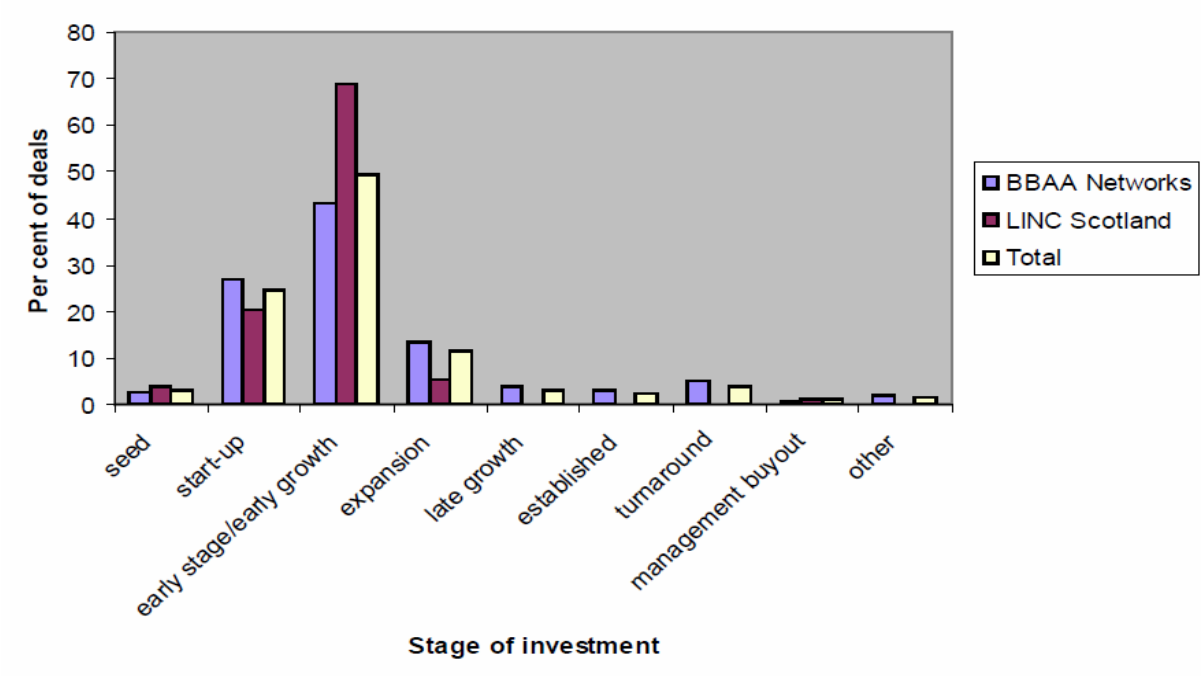

Figure 10 BBA p.30 (Mason and Harrison 2010)[19]

How entrepreneurs choose what type of investment they need depends on what is available in parallel with other perceived benefits and contractual issues. In addition to the financial cost and benefit (e.g. interest on a loan), angel and venture investors demand equity (e.g. through convertible preferred stock) which often dilutes an entrepreneurs shareholding (Hall 2005). Contracts may also include covenants for staged financing, rights of first refusal, anti-dilution clauses, board rights and so on (Denis 2004). Many investors also provide support via access to expertise and contacts that can demonstrably help the new venture development. All these factors influence the incentives for entrepreneurs to secure finance.

Organised equity finance is a fairly recent phenomenon compared to the history of industrial emergence. Throughout history, even before the emergence of venture capital, entrepreneurs have been successful at building businesses and contributing towards the emergence of industries. Entrepreneurs are often associated with resourcefulness capable of overcoming or circumventing potential barriers (Hugo and Garnsey 2005):

> '...it is difficult to identify a single factor that can account for entrepreneurs' ongoing ability to secure financing for their ventures. Indeed, perhaps the most striking aspect of the record of innovation over American economic history is the flexibility that technologically creative entrepreneurs have exhibited in adjusting their business and career plans so as to obtain financing for, and extract the returns from, their projects.' p.27 (Nairn 2002)

[19] The BBAA includes a review of the performance of business angel networks. While not all business angels use networks or syndicates, around a quarter use networks for all their investments, and 40% made some of their investments through such networks (Mason and Harrison 2010 p.35).

It is perhaps the hope that more organised equity finance removes the need for entrepreneurs to have specific fund raising skills, when they could be engaged in firm and industry building activities. But even with organised entrepreneurial finance the need to raise funds seems to be a cause for concern as it regularly diverts entrepreneurial activity away from value creation and capture activities. We now go on to discuss incentives to invest and the means to invest from an investor centric perspective in more detail.

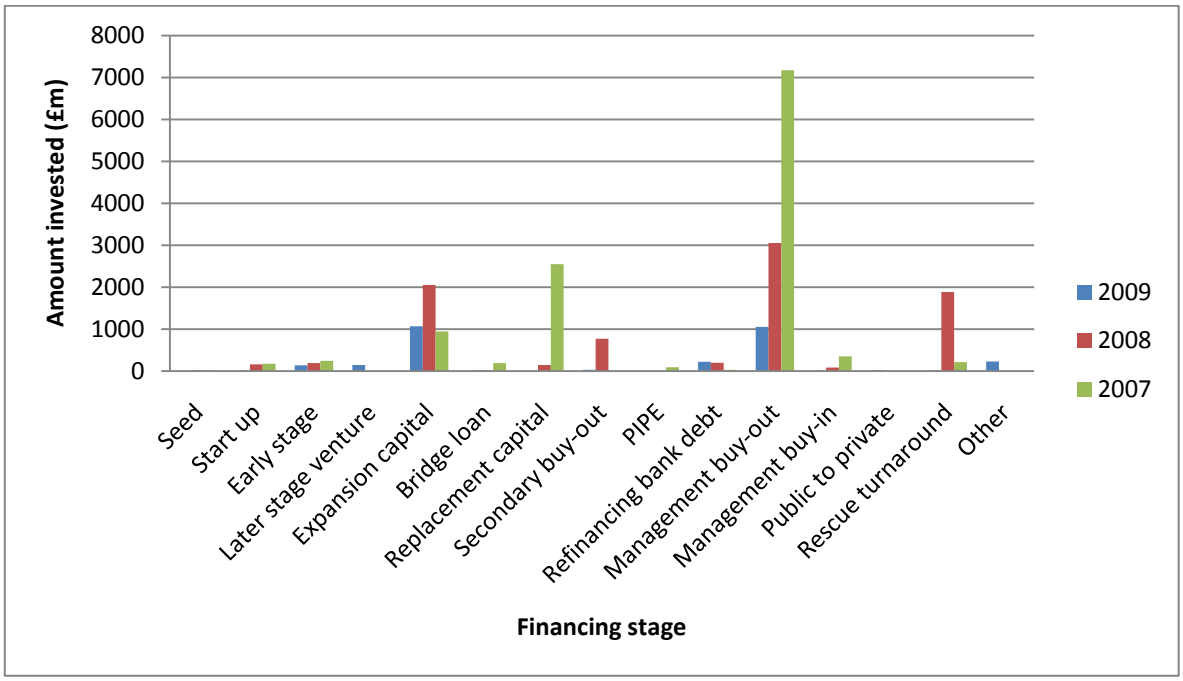

Figure 11 UK Investment by financing stage (BVCA)

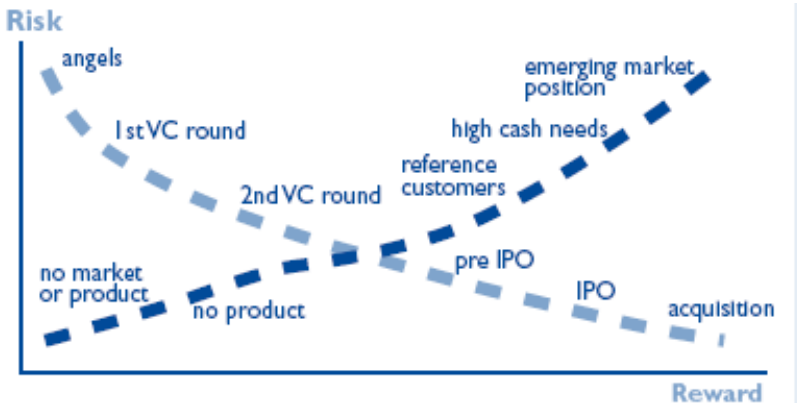

Figure 12 Adapting the risk/reward ratio: Angel and venture investors only accept higher risks if their intervention can convert higher risks to higher rewards (Gill, Minshall et al. 2007) p.46)

4.2 Incentives to invest

The main incentive for the majority of investors is to secure a competitive financial return. These returns compete against alternative investment opportunities as venture fund-managers (VCs) serve not only entrepreneurs, but also a pool of investors who supply capital to VCs:

> 'But what determines the *supply* of venture capital? Simple: the willingness of investors to provide money to venture firms. This willingness in turn hinges on the kinds of returns these investors expect to receive from their venture activity compared with what they think they can earn from other investments...' (Gompers and Lerner 2001) p.119

As the majority of investors are interested in securing competitive financial returns, we can identify several factors that impact returns and therefore the incentives of investors. For instance, while financial returns are the most used success measure in corporate venture capital (CVC), many also need to maintain a relationship and interactions with the parent corporation which can influence their incentives to invest (EY 2010).

Pipeline

As discussed in the previous section, different kinds of finance are appropriate for different firms, and external equity finance like venture capital, corporate venture capital and angel funding all seek ventures with potential for high growth. Many equity investments have a strong regional focus reflecting the need to be located near perceived potential investments (Mason and Perrakis 2009)(Figure 13). It has been reported that many VCs tend to shift from being a generalist to adopting more of a sector focus as the organisation matures, which can result in a wider geographic focus (Mason and Perrakis 2009). While UK government has introduced regional venture capital funds in areas not know for availability of equity finance, this approach has not proved effective in stimulating indigenous entrepreneurship (Mason and Perrakis 2009). Entrepreneurs have also been known to relocate in order to access appropriate finance (Zook 2005 in Mason and Perrakis 2009 p.28).

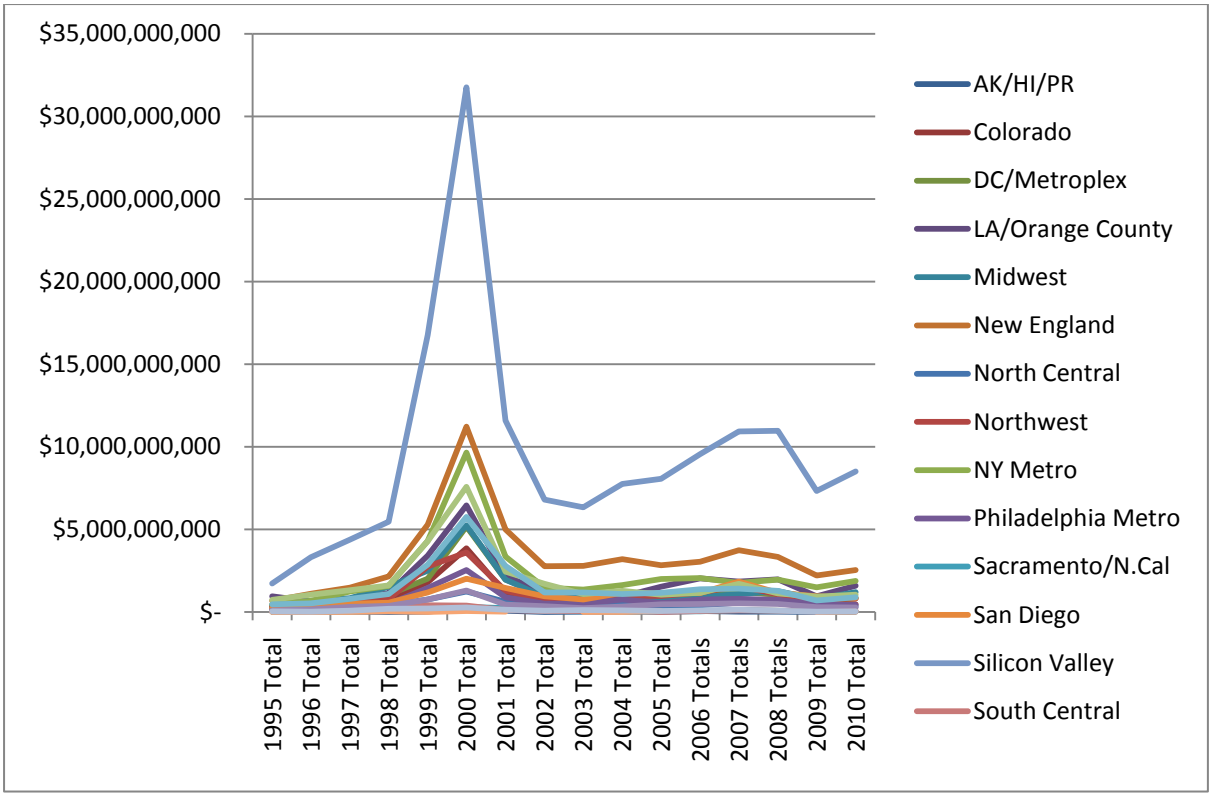

Figure 13 US Venture Capital Investment by Region (Source: PWC Money Tree)

Measuring investment performance

A common measure of return on investment is the internal rate of return (IRR). The IRR fluctuates over time and across different stages of investment (Figure 1). The IRR has been criticised for incentivising the wrong type of behaviour as it can mislead investors about the attractiveness of a project as 'internal rates of return conflate rewards for risk with returns for patience' (Kay 2010). Nonetheless the IRR remains a popular instrument for indicating the success or failure of an investment which can be applied to individual investments or a portfolio of investments. While IRRs are often projected by investment funds to attract capital, these projections are inevitably uncertain.

Returns vary depending on several factors including stage of investment, time and location of investment, and sector focus. For example returns from earlier stage investments have been particularly poor compared to later stage investments (Figure 14). This historical trend discourages continued investment in early stage investment. Due diligence is a roughly fixed cost irrespective of the size of the deal, which also incentivises larger deals for the same cost and these larger deals are typically later stage (HMTreasury and BIS 2010).

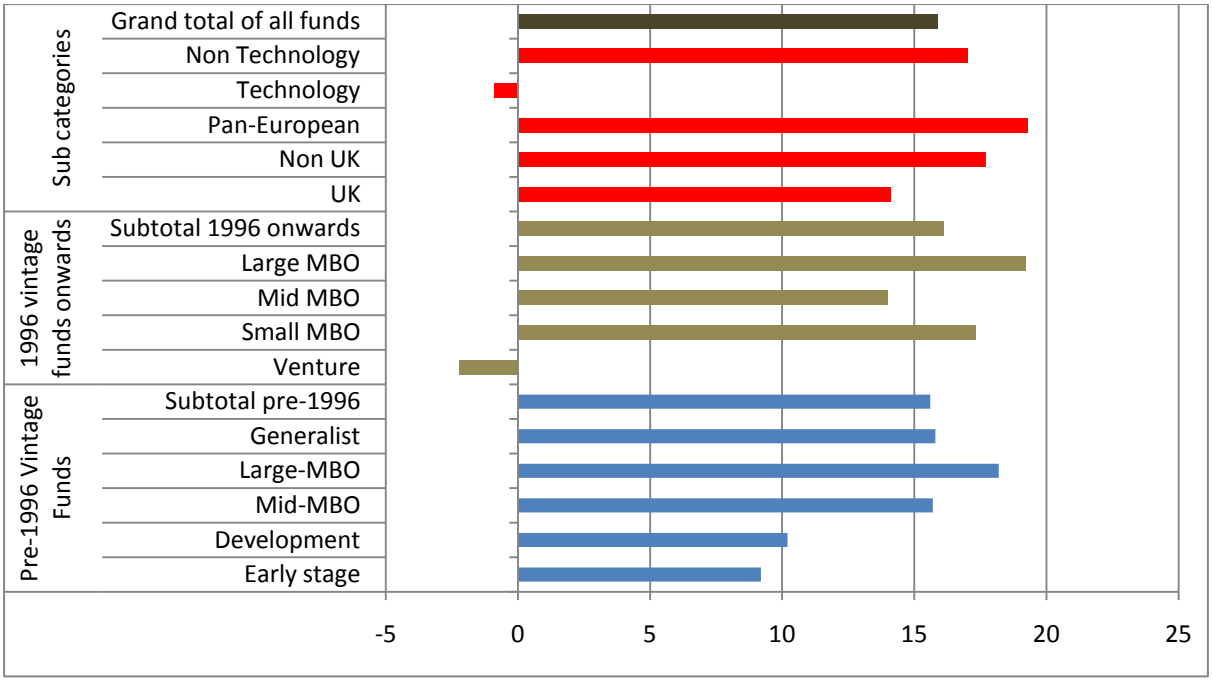

Figure 14 Since inception performance by investment stage and subcategories to December 2009 % pa (BVCA 2010) p.5

Information asymmetry

The success of an investment will depend on the quality of 'deal flow' i.e. investment opportunities in ventures. The search process of finding promising deal flow suffers from information asymmetry as the entrepreneur frequently has better information about their venture than the investor (Hall 2005). Knowing how much to disclose not only influences investors but also your competitors, but 'Even if the entrepreneur understands the value of the opportunity, the project will go unfinanced if he or she cannot convey this information to a potential financier' (Lerner, Shane et al. 2003). Information problems can lead to an increasing cost to entrepreneurial financiers, particularly for early stage investments with a lack of track record and demonstrability, as investors have difficulty distinguishing between good and bad venture investments which increases the cost for all i.e. a "lemons" market[20] (Hall 2005). Under these conditions it is perhaps not surprising that investor's value credibility and a track record even if in a previous venture. Research indicates first time entrepreneurs find it particularly difficult to raise equity finance compared to serial entrepreneurs (Gompers, Kovner et al. 2010).

After investment, staging (i.e. release of funding in tranches against meeting of specific milestones) is often introduced as a way of maintaining contact with an investee and so improving information transfer between investee and investor. In addition to information asymmetries, there can be delays in information as investors wait to see the returns on their investments. This can lead to imbalances between the supply and demand in venture capital (Gompers and Lerner 2001).

[20] As described by Akerlof (1970)

Investor influence on venture performance

Empirical studies reveal inconsistencies on the impact of venture capital on venture performance. For example 'good VCs' are assumed to have more successful portfolios due to superior search methods for high growth ventures and offering more support. However this performance difference has only been identified by venture capitalists who invest in the ventures of first-time entrepreneurs. This effect disappears for entrepreneurs with a track record of success, when '...the company is no more likely to succeed if it is funded by a top-tier venture capital firm than one in the lower tier' (Gompers, Kovner et al. 2010) p.19. Despite this, the study finds lower firm valuations by first tier VCs compared to second tier VCs regardless of the entrepreneur's track record. Multivariate analysis shows survival rate of firms is 7.6% lower when firms received finance from VCs, and 11.2% lower when they received business angel finance (Cowling and Murray 2010). While the involvement of equity investors may reduce an entrepreneur's likelihood for short run income at the expense of longer term growth, the presence of investors on the board may increase the likelihood for conflict (Cowling and Murray 2010). Other studies suggest Venture Capital is 3-4 times more powerful than corporate R&D in delivering innovative activity as measured by patents, though this research refers to VC from the late 70s to the mid-90s when VC was 3% of corporate R&D but responsible for around 10-12% of privately funded innovations (Kortum and Lerner 2000).

Venture capital investment often influences firm strategy as investors seek rapid returns:

> '...after involvement of a venture capitalst, firms switch from innovation to commercialisation of their products and therefore are able to realise superior growth rates...higher innovativeness of venture funded firms is due to the selection process of the venture capitalist prior to the funding rather than to the venture funding itself.' P.151 (Engel and Keilbach 2007)

The financial needs of capital investors (e.g. limited partners such as pension funds, high net worth individuals, foundations and so on) in venture capital may compel the VC (general partner) to focus on a particular investment time frame and exit which does not necessarily fit with the productive needs of its portfolio investments. This separation of ownership and management risks sophisticated 'principal-agent' problems where the goals of different parties can conflict (Hall 2005).

Exit

After the initial cash injection in an investee firm a return is typically achieved at the end of the investment relationship when an investment is liquidated either by taking the company public, selling the company in the private markets, or writing off the bad investment as a loss (Krohmer and Lauterbach 2009).

Whether an exit for the investor is always in the best interest of companies has been questioned. For example in a study of cleantech IPOs on the Alternative Investment Market, the share price fell after IPO even in cases where revenues were rising (Mueller and Garnsey 2009). This suggests an IPO was not perhaps appropriate for the long term interests of the

portfolio companies. Furthermore, it is suggested that premature stage-gates for development were imposed on firms at the very time when they should be flexible to respond to a changing business environment and opportunities (Mueller and Garnsey 2009). This may be a symptom of increasing divergence between productive and financial capital as suggested by Perez (2004).

The opportunity to exit via IPO is dependent on overall investor confidence in the public markets and their appetite for particular classes of investment whether by stage or sector. Investments can become under-valued in poor public markets or over-valued when public markets boom (Gompers and Lerner 2001). Long waves are discussed in relation to means to invest in the next section of this paper, but are closely linked to the performance of public markets and thus opportunities for exit via IPO.

Financing contractual issues

Entrepreneurs can be influenced by financing contractual issues that can impact the scope and scale of investment they seek. Contractual issues between venture capitalists and limited partners (capital investors) can also complicate investment decisions in otherwise attractive portfolios (Denis 2004).

Mania and crowding

At times investors have been known to crowd into particular streams of investment categories. The likelihood of a belief cascade formation has been associated with a lack of information and the exuberant pursuit of classes of technology stocks. Investor crowding/herding (e.g. canal mania, railway mania, fibre optic mania, etc.) is linked to problems of investment in a narrow selection of firms which can damage the evolution of an industry (Nairn 2002; Goldfarb, Kirsch et al. 2007). This can result particularly when investment decision makers lack information about the viability of entry strategies of new firms which can allow a particular investment strategy (correctly or incorrectly) to cascade (Goldfarb, Kirsch et al. 2007). This study showed a halt in investment as the investors in the dot.com bubble realised they were backing firms with an entry strategy which was inappropriate for the industry, instead of immediate modification of their investment strategy (Goldfarb, Kirsch et al. 2007). Crowding into particular streams of investment can also have an impact on returns as market opportunities become saturated.

4.3 Means to invest – raising capital

Capital is derived from a variety of sources for equity finance. Typically business angels invest their own capital, while venture capitalists seek capital from other funds, banks, insurance companies, pension funds, corporate investors, individual investors, government and other institutions (Mayer, Schoors et al. 2005). For example corporate venture capital has contributed between 6-16% of capital compared to total venture capital (Figure 15). Where capital is sourced seems to depend on country specific characteristics, for example:

> ***Outside market systems*** e.g. US and UK (liberal market economies) – where there is a clear separation between ‘owners’ and ‘managers’. Emphasis on shareholder value leading to ‘downsize and distribute’ practices.

Inside market systems e.g. Germany – where the separation between 'owners' and 'managers' is less strict. Emphasis on stakeholder value and 'retain and reinvest' practices.

While these are fairly crude distinctions, they are suggestive of the impact of different social systems existing between countries. As a result banks play a more central role in financing firms in Germany than Britain and are the major external source of funds for firms (Mayer, Schoors et al. 2005). In 2001 bank loans represented 95.54% of corporate credit in Germany compared to 62.96% in Britain and 44.57% in the US (Siebert, 2004 p.29 in (Casson, Martin et al. 2008). The outside market system has been argued as the most appropriate system for radical innovation, especially sectors characterised by novelty, appropriability and visibility (Casson, Martin et al. 2008). The inside market system is associated more with the development of 'middle technology' firms as it is a better environment for organisational learning and cumulative innovation (O'Sullivan 2001 cited in Casson et al).

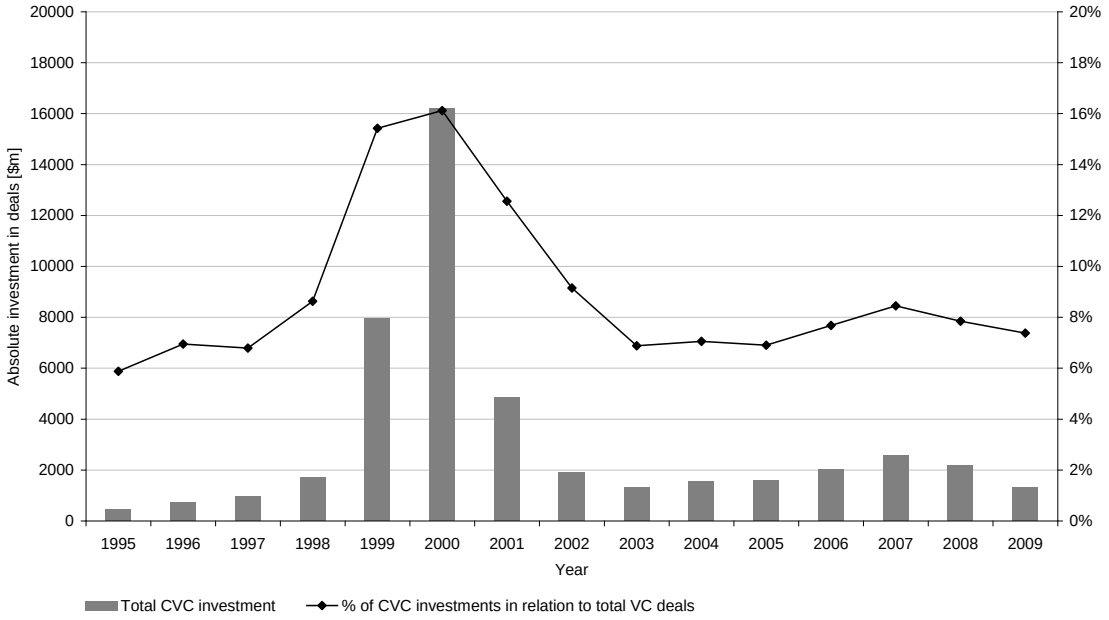

Figure 15 Investments of CVC in the U.S. (Xia, Livesey et al. 2010) p.14

Regulatory restrictions and tax incentives on investment

A change in regulatory restrictions can have a large impact on the availability of capital. For example in the U.S. the Department of Labor lifted the restrictions on pension fund investments in venture capital in 1978 which resulted in a boom in fund-raising for the sector (Gompers and Lerner 2001)(Gompers and Lerner p.123). During this period returns declined due to a steady demand for venture capital while supply of capital rapidly increased. Capital gains tax theoretically has an impact on business angel investment and the contribution of high net worth individuals to the availability of capital for other types of venture investment.

As a reaction to reduced capital resulting from poor returns in early stage investments the UK government has introduced a number of tax breaks to make returns more favourable to

investors e.g. Venture Capital Trusts (VCT)[21] and Enterprise Investment Schemes (EIS) [22] (Gill, Minshall et al. 2007). Public funds now participate in around 42% of venture capital deals in the UK (Pierrakis 2010). However it is questioned whether public financing would ever invest in ventures otherwise ignored by other financiers (Peneder 2008). Public and private partnerships in financing are widely viewed as a way of boosting entrepreneurial financing without creating competition between public and private entities and avoiding other problems associated with publicly led investments e.g. capped investments (Lerner 2009; Mason and Perrakis 2009).

Public markets

The FTSE All Share Index is a representation of broad investor confidence, which in turn is linked to the ability to raise venture capital funds (Figure 16). Investor confidence is linked to mania and crowding as discussed previously (p.28). Public markets can inflate or constrain the availability of external equity financing,and the source of financing can influence firm development. For example in biotechnology: 'Agreements signed during periods of limited external equity financing are more likely to assign the bulk of the control to the larger corporate partner, and are significantly less successful than other alliances.' (Lerner, Shane et al. 2003) P.411 A study of Cambridge technology firms found them highly sensitive to cyclical trends in the economy, in part due to cycles of funding availability (Drofiak and Garnsey 2009). Even though technology ventures have demonstrated some resilience in the past[23], they have been showing signs of contraction during the recent economic downturn.

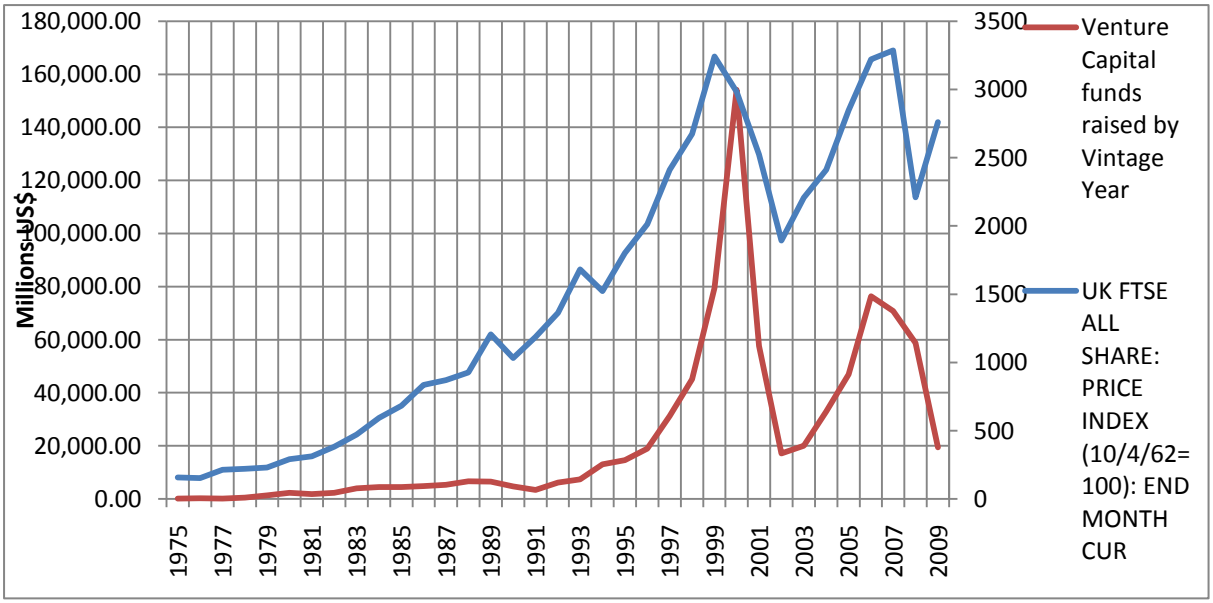

Figure 16 FTSE All Share Index (RH axis) and Global Venture Capital (LH axis): Sources: Office for National Statistics and Thomson One

[21] http://www.hmrc.gov.uk/guidance/vct.htm

[22] http://www.hmrc.gov.uk/eis/ (also see http://www.hmrc.gov.uk/research/report.pdf for an evaluation of the scheme). Past research suggested more than half of venture investors were identified as tax exempt which would make them ineligible for such a scheme, but this research has not been recently updated (Poterba 1989 in Denis p.317).

[23] Cambridge had few significant internet businesses at the time of the dot.com boom and bust and so showed some resilience to the dot.com boom and bust. Previous downturns have been associated with the establishment of fewer, but more resilient firms.

4.4 Impact of long waves on incentives and means to invest

Understanding the influence of long waves on the incentives and means to invest is complex as long waves are an aggregation of economic activity at mutiple industrial levels. There is evidence suggesting long waves impact the availability of external equity financing, which in turn can impact firms and industry (Gompers, Kovner et al. 2008). Long waves are associated with fluctuations in production and prices in addition to structural changes (Mensch, Coutinho et al. 1981; Freeman and Louca 2002). There is disagreement about the shape of long waves in the economy, with Kondratieff initially suggesting a sinusoidal pattern which Mensch revised to a series of sigmoid trends (Figure 17). These waves represent industrial fluctuations. While patterns on an aggregate level do emerge, a study of change over time presents challenges as while some recurrent themes can be identified in different time periods, change itself fundamentally alters the business environment making comparisons between different time periods problematic:

> 'Nature is cyclical, but the cycle is not the renewal of the same process again and again. And, since change is permanent and irreversible, time repeats never repeating.' (Freeman and Louca 2002) p.3

However there are features of industrial and broader economic change which seem repeatable so offering a basic framework from which deviations are identified which in turn yield useful insights.

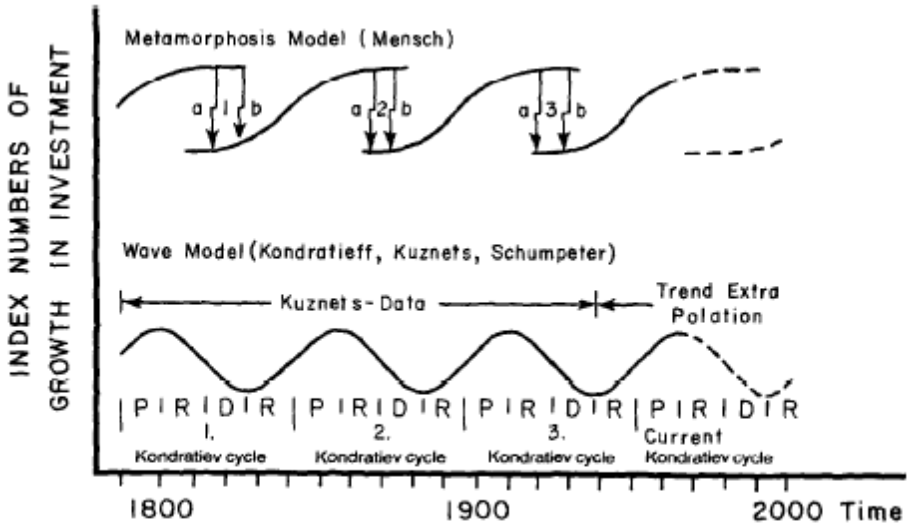

Figure 17 The metemorphosis model of long-term industrial fluctuations (Mensch p.277

Mensch theorises that '...basic innovation comes from prior lack of innovation, and the subsequent devaluation of capital goods dedicated to old lines of business, and a subsequent shift in the propensity to invest in innovation' (Mensch, Coutinho et al. 1981) p.282. This theme has been built upon by Perez:

> ‘Financial capital becomes ready to take risks in it [*next technological revolution*], precisely because the previous trajectories had approached exhaustion....The forces helping this exploratory process are crucial for the emergence of the next technological revolution and for the articulation of a new paradigm. This is especially so given that the overadaptation of the environment to the established paradigm has been systematically excluding, underestimating or marginalising the innovations that fall outside the established trajectories.’ P. 88 (Perez 2004)

She goes on to explore the interaction between technological, economic and institutional change as drivers to system dynamics which cause long waves in the economy. These long cycles are associated with techno-economic paradigm shifts originally described by Freeman (1992), and alterations in industry structures[24]. An entire cycle spans around half a century, with each cycle starting at the end of a prior cycle (Figure 18).

Definitively demonstrating cycles of paradigmatic shifts and exploring their processes remains problematic empirically as these shifts are manifestations of smaller changes which coincide to create an aggregated wave of activity. Perez suggests a systems based approach linking economic, institutional and technological change as the determinants of wider industrial change (Perez 2003).

[24] ‘A decade back, 22 computer outfits made the list. This year the count is 59 and rising, and computer-related businesses have continued to rise on the lists. Ranked for market value, Microsoft climbed from 373rd place to 4th. Intel, 498th in sales ten years ago, has risen to 40th.’ Forbes 500 – 1997

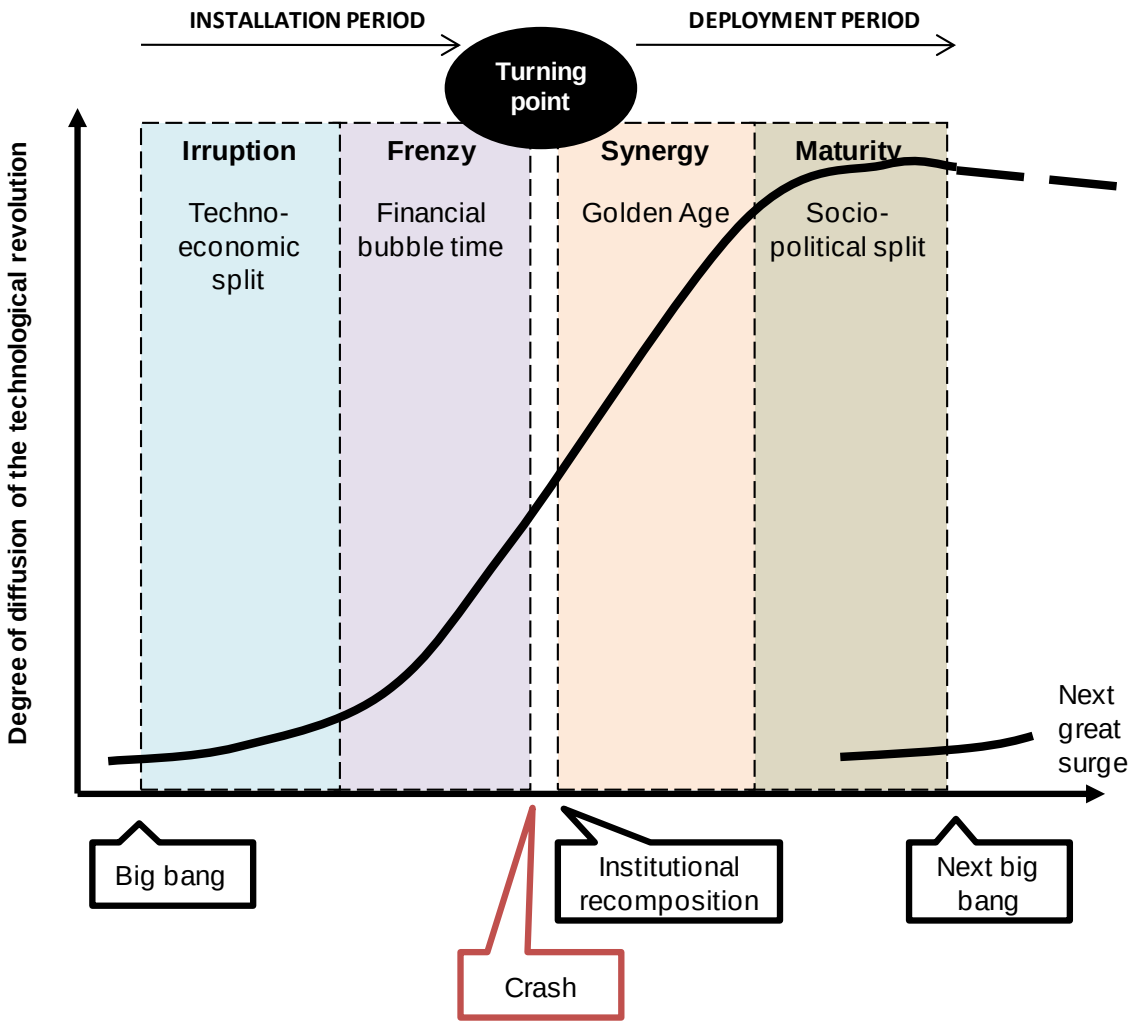

Figure 18 Recurring phases of each great surge in the core countries (modified from Perez 2003 p.48)

4.5 Industry level finance

Investors rarely invest in firms without evidence of industrial legitimacy and growth. Finance needs to be available to build the most appropriate industrial structures at the right time. If an industry structure becomes defined too early, the variation in solutions will be limited. If it is defined too late, effort may be wasted on non-dominant designs and entrepreneurial opportunities may move to other regions as industry consolidates.

Acquiring definitive figures on spend to create industrial structure excluding finance for new firms remains incomplete. As an indication of the scale of this type of investment fig 19 shows UK government spending on activities associated with low carbon technologies. While earlier investments in low carbon sectors were dispersed across departments, the government has now consolidated spending within the Department for the Environment and Climate Change (DECC).

	£'000		
	2007-8	**2008-9**	**2009-10**
Fuel poverty	361,795	399,894	429,487
Carbon Trust	87,866		
Energy Saving Trust	28,633	35,882	38,525
International Window of the Environmental Transformation Fund		50,000	100,000
Climate change research	19,033		
Global Threat Reduction programme	40,601	35,943	36,044
Environmental Transformation Fund	33,892	68,921	50,858
Regional Development Agencies		40,800	45,824
Low Carbon Buildings Programme		5,731	38,841
Carbon Budgets (includes Low Carbon Investment Fund and elements of Carbon Trust not in other lines)		49,279	102,911
Carbon Capture and Storage		6,459	9,309
Energy Efficiency Loans			15,762
Boiler Scrappage			20,601
Other programme spend		63,448	64,882
TOTAL	**571,820**	**756,357**	**953,044**

Figure 19 DECC expenditure on low carbon programmes

Some of the instruments shown in Figure 19 relate to market incentives, such as the Low Carbon Buildings Programme which offered grants to homeowners and organisations for renewables. Others were focused on educating the market through the Energy Saving Trust and Carbon Trust. This offers some insight into the kinds of industry and market building activities that occur in addition to funds for new ventures.

5 Discussion

The literature review reveals the importance of context when exploring the link between finance, innovation and emerging industries. As is often described in research methodology texts, theory development is as much about identifying phenomena as understanding when they are likely to arise (Snow and Thomas 1994; Carlisle and Christensen 2005).

The literature indicates that many more business ideas are generated than successfully commercialised; therefore suggesting that factors influencing the emergence of an industry occur predominantly outside the science base assuming a certain threshold of activity is achieved. New firms are associated with the introduction of radical and disruptive innovations that typically punctuate the early stages of industrial emergence, though it is also recognised that funding new firms alone is insufficient for industrial emergence. Entrepreneurial finance is a critical resource in the development and growth of many new firms.

Much of the work on entrepreneurial finance can be split broadly into two groups:

- Work examining the relationship between entrepreneurial finance and the ventures who seek investment
- Research exploring the macroeconomic impact of entrepreneurial finance

To date few works have attempted to understand the role of finance on the emergence of industries. In part this can be explained by the complexity of studying emerging industries, as identified in a recent review (Forbes and Kirsch 2010). While entrepreneurial finance includes a range of financial instruments, the majority of work has focused on venture capital and public markets as these also have the most data. Nonetheless the literature indicates several features of entrepreneurial financing that may affect the rate of industrial emergence, which our work is continuing to explore in more depth with the support of qualitative and quantitative data. Of concern is the ability to direct resources towards those activities most likely to contribute to the emergence of an industry. This requires a more complete perspective of industrial emergence rather than a reliance on a linear innovation process where funding gaps are identified and filled. The literature for example suggests entrepreneurs may experience greater difficulty accessing required finance when they are first time entrepreneurs and operating in emerging industries. While declines in the availability of entrepreneurial financing may occur, they do not necessarily reflect a decline in the financing needs of investable firms. Instead the supply of entrepreneurial finance seems predominantly driven by other factors in the business environment, such as the confidence in public markets. In addition to the amount of financing available, further work is needed to understand the implications of information delays regarding the performance of investments, the advantages and disadvantages of introducing measures enabling information transfer between investor and investee, plus positive and negative effects of investor mania on industrial emergence.

The entrepreneurial financing industry continues to release reports arguing more money will lead to more innovation and the creation of new industries, yet the literature suggests the relationship is not as straightforward as such claims suggest. Our ongoing research aims to show the complex relationship between entrepreneurial finance and emerging industries, and the limitations and strengths of entrepreneurial finance in supporting emerging industries.

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