CARDIFF UNIVERSITY

INVESTMENTS AND INNOVATION: REGIONAL VENTURE CAPITAL ACTIVITY, BUSINESS INNOVATION AND AN ECOLOGY OF INTERACTIONS

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Abstract

This research adds to the growing literature from recent years on innovation finance, innovation systems, and regional economic and innovation policy. Although the role of business has been seen as critical within the regional innovation system, the role of business financing intermediaries has received considerably less attention despite its recognised role as a central actor of the system. This research focuses on an innovation player that seems to have been neglected by scholars to date, namely the venture capital industry. The research examines the role of different types of venture capital, public and private, in fostering innovation at the regional level. In examining this relationship, this thesis empirically analyses the characteristics of 4117 investments deals made to 2359 companies, the innovation outputs of these businesses and the responses to a survey of 50 venture capital professionals. The contribution of this thesis is threefold:

First, this thesis investigates whether and how the supply of private sector venture capital and supportive public interventions has changed the availability of venture capital at the regional level. It examines the combination of venture capital in the UK regions by providing a detailed analysis of the extent of venture capital public dependency in each UK region. It also elaborates on the potential implications of the public sectors's domination in venture capital provision in several UK regions. The regional dimension of the analysis is of special interest as it is the first comprehensive analysis of the source of VC investments (public or private) for each UK region. From a regional perspective, the UK now appears to have two venture capital markets. In London, the South East and, to a lesser extent, the East of England, private sector investors dominate investment activity. This contrasts with the remainder of the UK where the venture capital market is underpinned by extensive public sector involvement.

Second, this thesis also investigates the role of venture capital in innovation using patents as a proxy variable for business innovation. In this way, it contributes to the literature by analysing the relation between patenting practices of venture capital backed firms, paying particular attention to two aspects: first, the company's acquisition of venture finance and progress through the venture capital journey and second, the relationship between patent practices and source of venture capital finance (public or private) in UK regions. The analysis shows a clear relationship between venture capital and patents. Companies with patents are more likely to secure follow up venture capital finance compared with companies without patents. The econometric analysis results also suggest that UK companies with moderate public venture capital support are positively associated with patents while companies with extensive public venture capital support are negatively associated with patents, compared to companies with solely private venture capital support

The final part of the thesis investigates whether the environment in which funds operate may explain observed differences in the ability of these funds to invest in companies with the potential to innovate. It does this by examining the ecology of interaction between venture capital and regional innovation systems. This is the first detailed empirical investigation of the relationship between different types of venture capital (private or public) and other players of the innovation system such as universities incubators, research institutes, and regional authorities. Three important findings emerge from this analysis. First, venture capital public dependence is strongly and significantly associated with higher volumes of interactions with the outside world. The more publicly dependent a fund is, the more it interacts with other players of the innovation system. Second, the role of

proximity is still important within the VC industry. Venture capitalists from both the private and the public sector, are more likely to interact with their counterparts from the same region. Third, there is evidence to suggest that operators of publicly backed funds are lacking close connections with their counterparts from the private sectors. This may have implications for their ability to approach and attract private heavy weighted venture capital funds and limited partners that can provide follow on investments or raise further funding for the fund.

Although publicly backed venture capitalists interact to a greater extent than the private counterparts, they experience less success (measured as financial performance of the fund or performance of their portfolio companies). It is widely acknowledged that interactions between venture capitalists and other players promotes tacit knowledge, but the results of this thesis suggests that interaction on its own is not enough to provoke success.

Overall, the findings of this research suggests that the distinction between the two venture capital markets in the UK, publicly or privately driven, is not limited to the volume or type of venture capital activity but also relates to the ecology of interactions between venture capitalists and other players of the regional innovation system. Since publicly backed funds do not promote innovation to the same extent that private funds do when they invest alone, UK regions that are heavily dependent on public investments may not be able to receive the benefits of a functional venture capital industry. However, regions in which public venture capital funds work closely with private funds, demonstrate a relatively higher volume of venture capital backed companies with the potential to innovate. From a policy perspective, this finding suggests that from an innovation point of view, free public standing investments should be minimised while co-investments between publicly backed and private venture capital funds should be further encouraged.

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1 CHAPTER 1: INTRODUCTION

1.1 Background

The study of venture capital (VC) and its relationship with regional development remains relatively underdeveloped in comparison to some of the core economic geography topics such as innovation, technology transfer, the knowledge economy and clusters. Venture capital is defined as "*independent, professionally managed, dedicated pools of capital that focus on equity or equity-linked investments in privately held, high growth companies*" (Gompers and Lerner, 2001:146) However, the role that venture capital plays in underpinning vibrant economies and supporting the entrepreneurial process is in fact well established (Zook 2000; Cooke 2001; Mason and Harrison 2002a, 2003). The impact of VC in innovation is also well documented mainly by studies undertaken in the United States. A study conducted by Kortum and Lerner (2000) suggests that increases in venture capital activity are strongly associated with increases in innovation activity and that by 1998 the provision of venture capital funding to firms accounted for about 14 percent of U.S. innovative activity. Another study, again conducted in the U.S by Puri and Zarutskie (2008), suggests that the amount of employment generated by VC backed firms accounts for nearly 10 percent of employment in the US in the late 1990s and early 2000s, steadily rising from about 5 percent in the 1980s. Illustrating the diversity of factors involved in the "innovation growth engine" of a leading region, namely Silicon Valley, Cooke (2003) highlights that venture capital is crucial as the means by which ideas have been screened and selected given a chance to fly as commercial products or services. Komninos (2004) regards funding organisations amongst the critical components of a regional innovation system and argues that integration takes place between the separate components of the regional innovation process: R&D, innovation finance, technology transfer, new product development, and co-operation production.

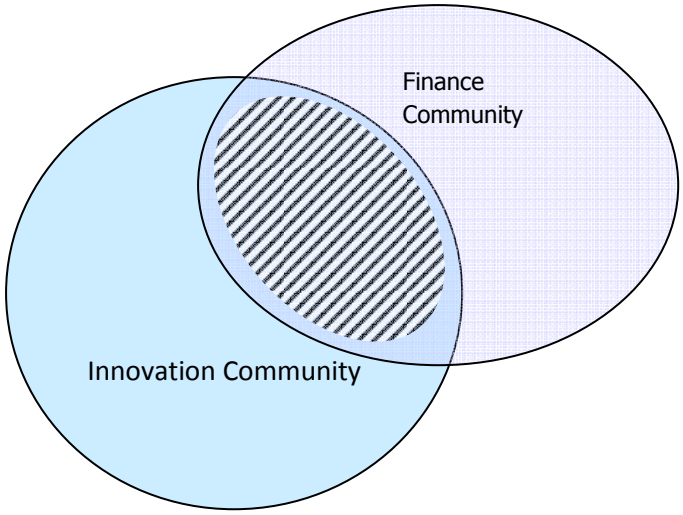
To date, most of the work conducted on UK venture capital and its regional impact, has been concerned with mapping the spatial distribution and take up of venture capital investment and drawing out the possible implications for regional development (Mason 1987; Mason and Harrison 2002a, 2003; Sunley et al. 2005, Murray 2007). Particular focus has also been given to the geographical heterogeneity of the finance industry which has highlighted the high concentration of risk capital investments in South East and East England (notably Cambridge), regions with, commonly

acknowledged, effective regional innovation systems in place (see SQW 'The Cambridge Phenomenon' 1985). It is believed that the concentration of both venture capital and knowledge based firms established in these two regions has provided significant advantages and opportunities for their regional innovation systems to flourish. Despite this strong belief, little attention has been given in documenting the actual impact of VC in innovation at the UK regional level or in mapping the linkages between the players of the regional innovation systems and VC community. This is thus the purpose of this study which focuses on understanding the role of the supply-side of the VC industry.

1.2 The area of the study

A strong regional innovation system can be seen as one with systemic linkages between different sources of knowledge production (universities, research institutions, and other intermediary organisations) and both large and small firms (Cooke 2003). These organisations contribute to the generation and diffusion of knowledge by establishing stable pathways of information with a distinctive group of regional players. Amongst these players, finance organisations have a prominent role and constitute an essential part of the innovation system as finance capital (defined broadly as capital that is invested in companies, new products, shares, stock etc.) is essential for any type of economic development. One particular source of capital, the VC industry, is an integral part of the innovation system as it tends to establish operational frameworks and close working relationships with other players of such system in particular universities, incubators, laboratories, research institutes etc. The VC community therefore, shares common ground with both the finance community and the innovation community. Figure 1 graphically illustrates the area of study of this thesis, the area in which the innovation and the finance community overlap.

Figure 1: Area of the study



Some of the most developed regional innovation systems (such as Silicon Valley and Cambridge) are widely acknowledged to have a range of networks, stakeholders and institutions that help explain their innovation and economic success (see Porter 1998, Cooke 2001, 2002). These regions typically host world class universities and research institutions which are actively involved in the creation of spin out firms and the exploitation of intellectual property rights. However, a further key part of the explanation offered for high levels of innovation and new firm creation is that these regions have attracted, or had easy access to, substantial venture capital investment through funds that are either based in the region or in an adjacent geographical area (SQW 1985). Boston and Cambridge (UK) are interesting instances of world-class science attracting critical mass in venture capital (Cooke 2002). It is believed that the extreme concentration of both venture capital and knowledge based firms established in these two regions has created significant opportunities for their regional innovation systems to flourish.

In recent years government policy in the UK has sought to encourage the replication of such conditions through the creation of publicly funded and inspired regional venture capital funds operated by the public sector or in a partnership between the public and private sector. Since early 2000, a number of government backed initiatives allowed many of the traditional players of the innovation system to benefit from the establishment of venture capital funds e.g. several universities established their own VC funds through the University Challenge Funds (UCFs) government scheme. Through another government initiative, regional development agencies (RDAs) set up Regional Venture Capital Funds (RVCFs) which invest together with private investors in companies that are based regionally. Furthermore, the regions of Wales and Scotland set up their

own regional venture capital funds (Finance Wales and Scottish Enterprise respectively). Although these schemes increased the supply of finance to regional firms, their role in enhancing prospects for regional innovation has not yet been evaluated.

1.3 Research questions

Despite the increasing importance of private equity as an asset class, the economic and social impact of the industry has not yet been fully understood. Among the growing literature, one strand is focused on the impact of venture capital in innovation. This thesis aims to make a contribution with respect to this topic which has been mainly influenced by the work of Gompers and Lerner (2001) on the impact of VC in innovation, the work of Cooke (1985, 1995, 2002, 2003a, 2003b, 2008), Cooke and Morgan (1994, 1998) on the regional innovation systems, and the work of Zook (2000), Mason and Harrison (2002a, 2003) on regional finance systems.

More particularly, this study examines the argument that the venture capital community plays an important role in the operation of vibrant and successful regional innovation systems, especially in the early, commercialization stage of the innovation process. Given this spread of venture finance activities amongst the key players of the regional innovation system, several research questions arise concerning the impact that these activities have in the innovation performance of the region.

Venture capital is not equally distributed in all parts of the UK and there is a concentration of venture capital activity in London and the South East (Mason and Harrison 2002a, Mason 2007). In order to allow all UK regions to benefit from a fully functional venture capital market, several regional VC funds were established with government support. Such funds aimed not only to address the regional equity gaps by increasing the availability of finance to small start-ups in each region (Murray 2007) but also to stimulate regional entrepreneurial activity and spill over effects (Mason and Harrison 2002a, Martin et al. 2002). Several years after the introduction of such schemes, a natural question is what has been the impact of these schemes in achieving their objectives. Therefore, the first research question of this thesis is concerned with changes in the availability of venture capital finance in each UK region:

1) *Has the supply of private sector venture capital and supportive public interventions changed the availability of venture capital at the regional level?*

Linked to the supply of venture capital finance is the second question of this thesis which examines the relationship between venture capital and innovation. More particularly, the literature suggests that there is a strong relationship between venture capital and innovation. Venture capital backed

companies are responsible for a disproportionate number of patents and bring more radical innovations to the market compared with firms that rely on other types of finance (Kortum and Lerner 2002, Gompers and Lerner 2001). In addition, there is a close relationship between the patenting behaviour of start-ups and the progress of those firms through the venture capital cycle (Mann and Sager 2007). The second question of this thesis therefore, investigates whether such a relationship is present in UK VC backed companies:

2) *Is a higher volume of VC investments positively correlated with higher volume of patent applications?*

The positive relationship between venture capital and innovation is often credited to the ability of venture capital professionals to select innovative opportunities and to also provide mentoring and support (Mondher and Sana 2009). The capabilities of public sector venture capital professionals however, are often questioned in terms of both selecting and "nurturing" business opportunities. Such professionals are often criticised for a lack of track record, limited experience and political motivations (Mason and Harrison 2003, NESTA 2009, Munary and Toschi 2010). Some relatively recent evaluations of the schemes have found that publicly backed funds underperform relative to private funds in terms of financial returns (NAO 2009), and that their impact in business performance has been marginal (NESTA and BVCA 2009). However, little is currently known about the role of these funds in stimulating innovation. A third question for this thesis as thus:

3) *Are publicly backed funds less effective in investing in companies with the potential to innovate, than private funds?*

Innovation policy approaches embrace the role of local linkages, tacit knowledge and interaction amongst different players (Morgan 1997). The benefits of interaction and networking between investors and investee companies are well documented (Hochberg et al. 2007, Sorenson and Stuart 2001, Sapienza and Amason 1993, Pinch and Sunley 2009). However, very little is currently known about how venture capital funds interact with other players of the innovation system, and whether there are differences in the extent and type of interactions between public and venture capital funds. The dynamics of the regional environment and the attitudinal and behavioural characteristics of the different types of venture capital funds (public or private), may influence the ability of different types of VC funds to identify and invest in companies with the potential to innovate. The final question of this thesis is therefore concerned with the ecology of interactions between different players of the innovation system:

4) *What is the ecology of interaction between venture capital and regional innovation systems, how does this differ spatially and why, and how does the venture capital community fit within the regional innovation system?*

1.4 Methodology

In order to test this hypothesis, this research is being conducted around two intertwined strands:

i) Measuring and analysing the volume and the role of VC in the UK regions:

By capturing and measuring the formal and partially the informal VC investment activity and also their role in the region's innovation performance this research analyses the significance of provision of venture capital in regional economies.

ii) Mapping the networks that enable VC in a region:

By tracing the relational networks of fund managers with other players of the innovation systems (e.g. universities, regional development agencies etc.) this research highlights the connections of the regional finance community with the mainstream players of the regional innovation system, its linkages to decisive circuits of human capital and influence on institutional architectures. It also investigates the spatial dimension of these networks and how the interactions between different bodies of the system are shaped by their specific regional contexts which are in turn influenced by economics, culture and governance characteristics of the region.

Adopting a two strand approach allows important results on the role of VC to be obtained and analysed, while steadily building a more complete and purposeful map of the networks and systems within which VC operates in the regions.

To answer the four research questions, the thesis employs a combination of research techniques. To measure the impact of publicly backed VC in the supply of finance at the regional level, commercial databases are used that contain individual VC deals. Investments are separated by region, type (public or private) and by year in order to unveil market trends. To examine the role of VC in the volume of innovation in the UK regions, the relationship between VC and patents creation using econometric models, is analysed. Finally, in order to map the ecology of interaction between VC and regional innovation systems, a survey of individual venture capitalists is conducted and the results are analysed in an econometric framework. This specific research methodology thus contributes to the debate between economists and economic geographers regarding the use of quantitative and qualitative techniques and their ability to identify impact and determine causality.

The research provides important new insights into, inter alia, the impact of different forms of risk capital (private vs public, formal vs informal etc.) on regional economies; the extent and type of network relationships which enable risk capital to achieve its impact within a regional economic system, and the potential policy options and prescriptions available to ensure that risk capital and VC investors maximise their impact and influence of regional economic growth, competitiveness and, crucially, innovation performance.

This thesis extends the existing academic literature in the following three ways: first, by using disaggregated data that has not been used before in academic studies, it is possible to examine the regional landscape of venture capital investments in the UK paying particular attention to the impact of public policy interventions; second, using a combination of aggregated and disaggregated data it is possible to examine the role of VC and public intervention in influencing the volume of innovation expressed through patents creation; third, using the respondents of 50 venture capitalists to a survey, it was possible to examine what may drive innovation performance differences between private and public funds by analysing the ecology of interaction between different types of VC funds with other players of the innovation system. Finally, the combination of these findings provide a better understanding of the spatial dimension of the VC activities and their role in the innovation environment of different UK regions.

1.5 Structure of the thesis

The thesis is organised as follows: chapter 2 provides a comprehensive review of the literature concerned with the main topics of this thesis. It first examines the role of the region in economic development and the uneven regional development. It then reviews the central theories of regional economic development, examining how they have changed overtime and emphasising innovation policy approaches. It then focuses on the role of finance in regional development and highlights the growing literature on the role of venture capital as a central means of financing innovation. It details the benefits of venture capital investments to the firm and also to the region as a whole. The chapter then concentrates on the regional dimension of the venture capital industry, outlines the localised effects of the industry in the UK and the main arguments of the closely linked “demand and supply side” and “market failure” debate. The policy responses to this failure are also outlined. The chapter concludes by reviewing the existing literature on the interactions and proximity of venture capital investments.

Chapter 3 provides the policy framework and reviews the “grey literature” of venture capital while also describing its evolution in the UK. It provides a historic overview of the UK venture capital

industry and positions it within the UK financial ecosystem. It then outlines regional imbalances in terms of VC activity and details policy initiatives undertaken as a response to these imbalances. The chapter concludes with an analysis of the impact of the current financial crisis in the VC industry.

Chapter 4 presents and justifies the research methodology employed by this study. It analyses the benefits and limitations of alternative methods of data collection and analysis used in undertaking the research. Influenced by the work of economic geographers and economists, this chapter draws particular attention to the debate related to the use of quantitative and qualitative analysis. The first part of this chapter illustrates the hypotheses to be tested and formulates the research questions. Part two, reviews the theoretical debates and philosophical assumptions that accompany the research methods. Part three includes a description of the quantitative and the qualitative methods used in this research. The final part of this chapter provides a detailed description of how this work has been conducted.

Chapter 5 presents the first set of findings of this thesis. It provides a detail empirical picture of the supply of early stage venture capital and it updates earlier evidence on the uneven geography of venture capital in the UK. In doing this, it examines the involvement of publicly backed funds in VC market and their contribution in the supply of VC finance at the regional level. This chapter addresses the first research question of the thesis which is concerned with the effect of increased government intervention in the supply of venture capital on the geography of venture capital in the UK in the early 21st century. This chapter provides a regional perspective on VC literature that to date has been primarily focused on the national level.

Chapter 6 examines the relationship between venture capital and innovation and analyses the likely impact of different sources of venture capital (public or private) on the innovation potential of companies. This chapter builds on previous empirical research which shows that venture capital spurs innovation through the creation of patents and increases in business R&D expenditure, and extends it to the UK level. The data allows the relations between financing and innovation outputs to be compared across regions and therefore seeks to illuminate the under-researched issue of regional variations in venture capital investments and the role of venture capital in fostering innovation. An important contribution here is the investigation of the relation between different sources of finance of VC funds and the innovation potential of the companies with which these funds are engaged. This chapter investigates the likely impact of these public interventions on innovation and provides answers to research questions 2 and 3.

Chapter 7 examines the role of the venture capital community in enhancing regional linkages and networks within the regional innovation system. It empirically maps the linkages and examines the extent of interaction between venture capitalists with other professionals in the regional innovation system. More particularly, this chapter studies the ecology of interaction between venture capital funds and other players in the innovation system by examining the responses to a survey completed by 50 UK based early stage venture capitalists. It measures the rate of interactions and explores their professional network of contacts in an attempt to understand the different regional environments in which venture capital funds operate. Therefore the aim of this chapter is twofold, first to measure how often UK venture capitalists interact with other players of the regional innovation system, and second, to investigate what parameters may influence the extent of such interaction.

Finally chapter 8 concludes the thesis by identifying the theoretical and empirical contribution of this thesis to the existing knowledge base. It also elaborates the policy implications of the research findings and provides a set of questions for future research.

2 CHAPTER 2: REGIONAL DEVELOPMENT, INNOVATION POLICY AND VENTURE CAPITAL: THEORETICAL APPROACHES AND HISTORIC OVERVIEW

The purpose of this chapter is to provide an overview of the academic literature concerned with the main topics of the research as outlined in the previous chapter. It reviews the theories related to uneven regional development and regional innovation policy. It also reviews the literature concerned with understanding geographies of finance, the role of venture capital in supporting innovation and interaction frameworks within the finance community. By tracing the different approaches taken to understanding regional development, innovation, financial practices and geographies of money, this chapter indicates how and why these literatures are related to the thesis.

The chapter begins by reviewing the central theories of regional development and innovation. It continues by examining the literature on financing business innovation, illustrating the characteristics of venture capital and its benefits to firms and regions. It then examines the literature on the role of venture capital in regional innovation and concludes by surveying the theories on interaction and their importance in minimising information asymmetries within the financial system.

2.1 Innovation and the regions

The changing nature of the region and its increasing importance, have become an important subject for debate. Regions (and places) have been at the heart of geographical discourse since the institutionalisation of the discipline (Paasi 1991). In the early 1980s, it was asserted that the region might be a fundamental basis of economic and social life. At the heart of this argument was the notion that the nation state was undergoing some form of crisis to which state management (and response) was required across a number of spatial scales (Deas and Ward 2000). The formation of Regional Development Agencies (RDAs) in the UK regions reflected the appeal of the notion that the nation-state had become increasingly dysfunctional and that instances of successful economic transformation had been organised around regional networks of institutions (Cooke 1995; Deas and Ward 2000). Indeed,

"since new successful forms of production – different from the canonical mass production systems of the postwar period - were emerging in some regions and not others, and since they seemed to

involve both localisation and regional differences and specificities (institutional, technological), it followed that there might be something fundamental that linked late twenty century capitalism to regionalism and regionalisation" (Storper 1997, p. 3).

By the 1990s the 'region' quickly emerged as a determinate 'space of competitiveness' (Brenner 1998), and it had widely been identified as a key territorial zone and institutional arena for the promotion and pursuit of competitiveness strategies (Bristow 2005). It has risen to particular prominence in the UK where RDAs have been explicitly tasked with the responsibility for making their regions 'more competitive' and akin to benchmark competitive places such as Silicon Valley (HM Treasury 2001, cited by Bristow 2010).

The widespread belief in the concept of regional competitiveness carries the implicit assumption that 'the region' is both clearly understood and unequivocally defined, which is not the case according to Bristow (2010). Regional geographers have long struggled to define the boundaries of their fundamental object of study to the extent that what actually constitutes a region remains an object of mystery (Harrison 2006). In recent decades, there has been a shift from the mainstream views and conception of region and cities as territorial entities with discrete regional systems of economy and leadership, to entities that are increasingly open and characterised by complex linkages between places both within and beyond their boundaries (Taylor et al. 2006). The new relational thinking in defining regional boundaries has impacted in the economic activity theories and economic geographers have been exploring alternatives to the strictly territorial sources of regional boundaries. The result is an intricate geographical mosaic of spaces juxtaposing instances of the knowledge and service economies and new pockets of affluence alongside the remnants of traditional industry and deprived neighbourhoods (Taylor et al. 2006). The regions provide an appropriate 'relational' space that allows for the sharing of tacit knowledge (Uyarra 2007). An economic definition of a region would focus on company production patterns, interdependencies and market linkages, and labour markets. A broader functional definition would add patterns of social interaction, including leisure, recreation and travel patterns. But however drawn, they are often unstable, changing their contours according to economic and social trends (Keating 1998).

2.1.1 Regional economic development theories

Malecki defines regional development as "*a combination of qualitative and quantitative features of a region's economy, of which the qualitative or structural are the most meaningful*" (Malecki 1991, p.7). He argues that the growth and decline, as quantitative changes in economic activity, gauge the

impact on region, in jobs and incomes, of decisions both from within and external sources. The qualitative attributes include the type of jobs – not only the number – and long-term structural characteristics, such as the ability to bring about new economic activity and the capacity to maximize the benefit which remains within the region. He continues by arguing that the standard theory of economic growth and development has concentrated on quantitative changes, despite an increasing awareness that regional growth depends, often crucially, on aspects that are understood only in comparison with other regions or nations. The facts of regional development suggest that it is not enough to rely on concepts of growth without an equivalent concern for the forces which permit growth to take place or prevent it from occurring (Malecki 1991).

Regional economic problems include inequality of income, employment rates, infrastructure and social inclusion. Growth rates, of income or of jobs, are customary indicators of regional economic differences (Malecki 1991). Malecki (1991) points out that:

'the fact that regions do not grow at equal rates, so don't provide equal numbers of jobs or hobs sufficient for those seeking employment is a complex issue '(p.12).

The regional differences found in developed countries can be summed up in Clark's observation "*prosperity is tied more to where you live*" (Clark 1988, cited by Malecki 1991). Analysis of the data on regional economic performance and innovation indicators shows that there are significant differences across regions in terms of economic growth, R&D intensity and innovation activity (for example see Frenz and Oughton 2005). Frenz and Oughton (2005) found that R&D and innovation activity are regionally concentrated. This is true especially for the UK and for other European economies. Moreover, the differences across regions seem to be persistent and to be related to differences in regional competitiveness as measured by labour productivity and GDP per capita. Using CIS data Frenz and Oughton (2005) found that there is also a significant variation across regions in novel product innovation, organizational innovation, patenting, R&D activity, employees with science degrees and other degrees, expenditure on machinery for R&D and cooperation with suppliers, universities and public research institutes.

2.1.2 Why some regions grow and develop faster than others?

The causes and effects of regional variations in economic performance and their link with innovation have attracted growing attention from various scholars: '*Thus, while national differences matter, regional differences within nations are a more important source of total variation in regional innovation and competitiveness than national differences'* (Frenz and Oughton 2005, p. 12)**.**

Endogenous growth models have specified business investment in knowledge (R&D) as an additional factor input to explain technological change, however, empirical studies show that this still leaves a significant part of growth unexplained. More particularly, empirical studies based on regional growth accounting models have shown that both R&D activity and total factor productivity (TFP) growth vary significantly across regions, which raises the question as to why there is a regional dimension to R&D and innovation activity (Frenz and Oughton 2005)? This question has been addressed by the literature on the geography of innovation and regional innovation systems. Drawing on this literature it is possible to identify a number of theoretical explanations of regional uneven development. These centre around different types of agglomeration economies, knowledge or R&D spill overs and the role of regional infrastructure.

2.1.2.1 External economies

Marshall (1890, cited in Frenz and Oughton 2005) drew a distinction between internal economies – which depend on the internal organisation, capabilities and management of the firm – and external economies – which depend upon the overall progress and development of the industrial environment in which firms operate. Marshall identified a number of sources of external economies, these include: pecuniary external economies, agglomeration economies; pools of skilled labour and what he termed 'industrial atmosphere' which is now referred to as R&D or knowledge spill-overs.

Pecuniary external economies

According to Marshall pecuniary external economies arise as a result of the expansion of production and the realisation of internal economies of scale. Provided markets are competitive, internal economies are translated into pecuniary external economies as firms lower prices in response to reductions in the cost of production. If production is geographically concentrated, reductions in a firm's costs that arise as a result of an increase in the scale of production will yield an external benefit for that region (though the benefits may also be reaped elsewhere).

Agglomeration economies

Agglomeration economies have the effect of shifting the cost curve of individual firms downwards, lowering barriers to entry and facilitating new firm formation. Improvements in local transport and infrastructure, public investment in the research base and the growth and development of related trades, including finance and venture capital, can all give rise to agglomeration economies. For example, the existence of a well-developed local supply chain can lower transport costs. It can also lower the costs of improving and refining inputs, as this frequently involves repeated interaction

between buyer and supplier and such interactions are easier and cheaper if they are local (Frenz and Oughton 2005).

Pools of skilled labour and human capital

Marshall argued that the geographic concentration of industry and related infrastructure encourages the growth of pools of skilled labour. The concentration of employment in specific industries within a geographic proximity provides a pool of skilled employees for firms. At the same time, the existence of an extensive and geographically concentrated set of job opportunities attracts skilled labour into the area, as employees know there are significant employment prospects. As the industry grows and develops, the capabilities of the workforce are enhanced via both formal and informal mechanisms. The Marshallian concept of pools of skilled labour was richly formulated to recognise the role of human capital and ingenuity in product and process innovation (Frenz and Oughton 2005).

Industrial atmosphere and knowledge spill-overs

Marshall also recognised the cumulative nature of knowledge creation, spill-overs and diffusion, describing these processes using the concept of "industrial atmosphere". With regard to innovation, industrial atmosphere speeds up the diffusion process, facilitating continuous improvements in technology and organisation. This idea of knowledge spilling over in a cumulative manner has been embodied in contemporary analysis of the geography of R&D and innovation, and in the literature on the economics and sociology of knowledge (Frenz and Oughton 2005).

Cooperation and networking

In his later work - *Industry and Trade* – Marshall stressed the importance of constructive cooperation between firms that results in a further type of external economy realised via networking relationships between firms and firms and other organisations. (Frenz and Oughton 2005).

The recent literature on the geography of innovation has extended Marshall's insights in a number of directions and provided a rich and formal analysis of the importance of geography in shaping innovation performance. As a result,

'there is now a compelling body of theoretical evidence to suggest that there is a strong regional or geographic dimension to innovation activity' (Frenz and Ougton 2005, p.26).

Interest in the role of external economies and spill over effects as an influence on regional growth has grown remarkably in recent years. Industry clusters policy approaches are based on the logic

that external economies shared by a group of collocated firms will elevate the level of competitiveness and rate of growth of the group overall (Rosensfeld 1996). The level of interest in external economies has been further bolstered by developments in mainstream economics, where increasing returns and externalities have become a central element in neoclassical growth and trade theory: '*Even economists, traditionally unconcerned with spatial issues, have begun referring to the advantages of cities and industrial districts as a possible explanation for externalities that drive the new endogenous growth and trade models'* (Feser 1998, p.284).

Much of the recent work has been concerned with the technological externalities, spill over effects, clusters, networking and the prominent role of universities and the public sector. The regional innovation systems approach has also covered the role of institutions, trust, tacit knowledge, social capital and governance. These approaches have significantly influenced the policy approaches to regional development.

The Keynesian approach, which has dominated economic development policy since the 1960s, has relied on income redistribution and welfare policies to stimulate demand in the less favoured regions (LFRs), as well as the offer of direct and indirect incentives (from state aids to infrastructural improvements) to individual firms to locate in such regions (Amin 1998). The neo-liberal approach which followed during the 1980s, focused on the market mechanism and sought to stimulate entrepreneurship through a variety of small-firm policies and to deregulate markets, notably the cost of labour and capital. As Amin puts it:

"*Keynesian regional policies, without doubt, helped to increase employment and income in the LFRs, but they failed to secure increases in productivity comparable to those in the more prosperous regions, and more importantly, they did not succeed in encouraging self-sustaining growth based on the mobilisation of local resources and inter-dependencies (by privileging selective sectors and firms, or externally-led growth). The "market therapy" has threatened a far worse outcome, by removing financial and income transfers which have proven to be vital for social survival, by exposing the weak economic base of the LFRs to the chill wind of ever enlarging free market zones, and by failing singularly to reverse the flow of all factor inputs away from the LFRs (i.e. no proof of price-seeking inflow of opportunities leading to regional specialisation in the appropriate industries)* (Amin 1998, p.3)."

2.1.3 Regional development and innovation

The literature in the fields of economic geography and technological development has placed considerable emphasis on trying to investigate the territorial development of innovation, in the national, regional, local or city level. As Komninos (2004) pointed out, this started with the "explosion" of the innovation process out of research labs and the consequent extension of the spatiality of innovation over the entire regional space. The growing body of literature on regional innovation and development was given the label of 'New Regionalism' (Lovering 1999). This describes the normative assertion of the region as the most appropriate scale for economic governance, whereby academics, policy-makers and consultants are increasingly focusing upon the region as 'the crucible' of economic development. In the 1970s and 1980s regional development policies had a simple sectoral focus on developing and attracting "high tech" industries and building science parks (Cooke 1985; Howells 2005). These industries tended to import high tech products from the laboratories based in more advanced regions mainly due to the fact that the highly skilled human capital was already based in such regions. Attracting exogenous investment or "smokestack chasing" was seen as a way of building up endogenous capacity, innovation and competitiveness (McCarthy 2000).

Quite often, such policies were successful in physically bringing large plants into the region and creating employment, but the regional supply chain had limited benefits. As a result, the impact of such policies was found to be very limited and inadequate for regional development (Cooke 1985), and did not significantly improve the region's innovative capacity. Whilst the impact of science parks in terms of innovative potential was found to be greatest in already "innovation rich" environments (Massey et al. 1992, cited in Howells 2005).

In order to overcome these issues, Cooke (1985) argued that an obvious redirection of regional policy was needed towards substantially improving regional innovation potential. He argued that the basic problem that regions faced was the lack of potential to encourage technical innovation. Cooke argued that because R&D is poorly represented in typical assisted areas and because such areas tend to depend on large plants in declining industries or on branches of firms producing technologically mature commodities, they are unlikely to contain the personnel or units capable of substantial and sustained innovative technological activity. In a context of competition from low-wage economies in traditional mass-product markets (for example, motor vehicles and consumer electronics), it behoves developed economies to exploit their elaborate knowledge-producing systems by developing markets for advanced technological products and processes (Cooke 1985).

Innovation policy was seen as a solution to this problem because of the link between innovation, growth and economic performance (Howells 2005). Howells (2005) argued that innovation poor regions will not benefit as much in terms of economic development and growth and that they will suffer in future rounds of innovative activity and investments and so can be locked into a vicious circle of innovation stasis or decline. Other scholars have also argued that regional policies needed more than conventional or incremental approaches and saw innovation as a faster speed towards the region's escape from its own path-dependency (see Cooke and Morgan 1998; Fuchs and Shapira 2005; Hassink 2005). The term "path-dependence" here is borrowed from evolutionary economics (see Nelson and Winter 1982) and has been adopted by the scholars of national and regional innovation. The concept of path dependence provides a theoretical framework within which to understand the different historical economic trajectories followed by different regions. Martin and Sunley (2006, p. 402) define path dependency as:

"a probabilistic and contingent process (in which) at each moment in historical time the suite of possible future evolutionary trajectories (paths) of a technology, institution, firm or industry is conditioned by (is contingent on) both the past and the current states of the system in question."

The concept of path dependence is intended to capture the way in which small, historically contingent events can set off self-reinforcing mechanisms and processes that lock in particular structures and pathways of developments (Martin and Sunley 2006). Martin and Simmie (2008) argue that the sectoral development of regional economies, evolves over long periods of time in a path dependent manner and that "as a consequence" condition the scope and possibilities of future development. However, Martin and Sunley (2006) note that whilst path dependency is an important feature of the economic landscape, the concept requires further elaboration if it is to function as a core concept in an evolutionary economic geography.

This debate led to the belief that a new set of policies was needed, aiming to promote economic competitiveness by mobilising the endogenous potential of the regions through efforts to upgrade the local supply-side infrastructure for entrepreneurship. According to Amin,

"an understanding of the economy as something more than a collection of atomised firms and markets driven by rational preferences and a standard set of rules. Instead the economy emerges as: a composition of networks and collective influences which shape individual action; a highly diversified set of activities owing to the salient influence of culture and context; and subject to path-dependent change due to the contribution of inherited socio-institutional influences" (Amin 1998, p.5).

2.1.4 From regionalisation to regionalism: the birth of regional innovation systems

Although during the 1980s and 1990s innovation was identified as a key driver for economic development by various scholars, another debate was emerging concerned with how to better stimulate such innovation. A new generation of regions has emerged throughout the world to meet the challenges of knowledge-based development and globalisation. These have variously been labelled "new industrial spaces", 'innovative milieux' "innovative", "innovating", or "learning regions", and "regions of knowledge". These different explanatory schemes were formed based on theories on innovating by networking (Cooke and Morgan 1994, Morgan and Nauwelaers 1999, Oughton et al. 1999, 2004), technology districts, innovative clusters and agglomeration economies (Porter 1990, 1994, 1996, 2000a, 2000b), regional innovation systems, tacit knowledge and learning regions (Cooke and Morgan 1994, 1998; Florida 1995; Lundvall 1996, Landabaso et al. 1999, 2001; Nielsen & Lundvall 2003), and more recently, intelligent cities and regions (Komninos 2004).

More particularly, Cooke and Morgan (1998) expanded the concepts of the evolutionary process of regions between regionalisation (a top down approach marking of boundaries by an overarching political administrative body) and regionalism (a bottom up approach which incorporates the cultural dynamics of an area with the political and economic systems). A principle feature of innovative regions is their capacity to create environments favourable to turning knowledge into new products, disseminating information, building organisational learning, integrating skills, and in the end generating innovations (Komninos 2004).

The bottom up perspective where a series of coordination and interactions between regionally based players such as private firms, public institutions and agencies seemed to be of much importance (Morgan 1997; Cooke and Morgan 1998). In such systems, much more focus has been put on the processes of improving intangibles which assumes the existence of regional strengths such as the capacity of regional firms to innovate; the quality of management; entrepreneurship culture; an institutional framework which encourages inter-firm and public-private co-operation; and a minimum level of R&D expenditures (Landabaso 2001). This debate led to the birth of a new concept, the "Regional Innovation System" (Cooke and Morgan 1994) that incorporates the evolutionary thinking of regional development and attracted particular interest in both academic and policy making communities including the European Commission (for example Landabaso et al. 1999, Oughton et al. 1999).

In order to explain such processes at the regional level, an emerging dialogue between innovation researchers, sociological scientists and economic geographers took place, and regionally-oriented

innovation policy approaches became popular during the second half of the 1990s (Koschatzky 2000). Within this context, the spatial dimension of innovation and learning received great attention in the economic geography literature. Innovation and learning tend to be conceived as socially embedded and spatially structured processes (Cooke and Morgan 1994) and most successful regional economies are those which are characterised by the capacity of firms and institutions to learn – in products, processes and organisational structures – and adapt to changing competitive pressures (Maskell and Malmberg 1999). Learning is seen as an alternative social process (Lundvall 1992) and learning through training has also been seen as significant factor. Howells (2005) argues that scientific knowledge is embedded in individuals and organisations, and bodies (especially publicly funded) should provide training and collaboration.

Innovation processes involve many different players and successful innovation may entail a transfer of technology - for instance, from a university or research centre to a company – but this is rarely an isolated event (Cooke and Morgan 1994). The speed and the success of the transfer almost certainly depends on other interactions, before and after the transfer itself. As Cooke and Morgan (1994) suggest innovation is first and foremost a collective social endeavour, a collaborative process in which the firms, especially the small firm, depends on the expertise of a wider social constituency than is often imagined (workforce, suppliers, customers, technical institutes, training bodies).

The institutional framework of such systems it is expected to consist of universities, basic research laboratories, applied research laboratories, technology transfer agencies, regional public and private (e.g. trade associations, chambers of commerce) governance organizations, vocational training organizations, banks, venture capitalists and interacting large and small firms. Moreover they should demonstrate systemic linkages through concentration programmes, research partnerships, value-adding information flow, and policy action lines from the governance organizations. These are systems that combine learning with upstream and downstream innovation capability and thus warrant the designation regional innovation systems (Cooke and Morgan 1998). Integration takes place between the separate components of the regional innovation process: R&D, innovation finance, technology transfer, new product development, and co-operation production. Komninos (2004) argues that integration also takes place between the physical, institutional, and digital spaces within which innovation process occur. He uses the term intelligent cities/regions to illustrate the multi-level localised system of innovation which assures the coherence of practice of organisations involved in product, process and organisational innovation (Komninos 2004).

2.1.5 Clusters policy

Porter asserted that geographic proximity between firms, located in what he referred to as clusters of industries, plays an important role in improving productivity and encouraging continuous innovation. Competitive nations, according to Porter, are made up of competitive regions, and competitive regions consist of localised collections of firms that share common factors, exchange information and yet still engage in rivalrous competition (Porter 1990). Clusters, which are defined by Porter (1998) as geographic concentrations of interconnected companies and institutions in a particular field, encompass an array of linked industries and other entities important to competition. Many clusters include governmental and other institutions – such as universities, standards setting agencies, think tanks, vocational training providers and trade associations – that provide specialised training, education, information, research and technical support (Porter 1998) all integrated within a given territorial dimension.

Porter (2000a) argues that clusters suggest that a good deal of competitive advantage lies outside companies and even outside their industries, residing instead in the locations at which their business units are based. This creates important new agendas for management that rarely are recognized. For example, clusters represent a new unit of competitive analysis along with the firm and industry. Clusters also represent an important forum in which new types of dialogue can and must take place among companies, government agencies, and institutions such as schools, universities, and public utilities.

The concept of the cluster attracted particular attention by policy makers around the globe and thousands of cluster initiatives were established, based on Porter's argument around regional competitiveness. However, according to Woodward and Guimaraes (2005) Porter's arguments have often been misinterpreted by policy makers who have seen his policy prescriptions as compatible with industrial targeting, while in fact Porter rejects targeting and argues that all clusters matter. Other scholars raised concerned related to the definition of the cluster concept, its theorisation, its empirics, the claims made for its benefits and advantages, its use in policy-making (Martin and Sunley 2001) and the relatively limited empirical evidence on Porter's work (Woodward and Giumaraes 2005). Martin and Sunley (2001) question why is that cluster have gate-crashed the economic policy arena when the work of economic geographers on industrial localization, spatial agglomeration of economic activity and the growing salience of regions in the global economy, has been all but ignored, and argue for a much more cautious and circumspect use of the notion of clusters, especially within a policy context. Finally, Adams et al. (2003) argue that many of initiatives that governments implemented in the area of promoting innovation at the regional level, such as

clusters, do not have a strong central narrative. Instead, policy seems to have been driven by vague concepts such as the creation of a "knowledge-based economy" and by a small number of individuals who have become skilled at promoting their own ideas.

2.1.6 Critical reflection on new regionalism and knowledge regions

Various criticisms have been levelled against the new regionalist school of thought from the 1990s onwards (Hudson and Odgard 1998; Lovering 1999; Hudson 1999, 2002; Robinson 2001; McLeod 2001; Leitner et al. 2002; Adams et al. 2003; Simonsen 2005) with a number of questions raised as to the viability of new regionalism policies in achieving their stated aims.

Lovering (1999) argues that this style of analytical and policy thinking is in fact deeply problematic as it fails to explain contemporary regional development in general. Correspondingly it is a poor general guide to regional policy formation. Lovering believes that the policies in question are most unlikely to make significant difference to the majority of the population of the regions in question as they prioritise one set of activities (those that can be presented as involving learning) and devalue others. As a result such policies represent a social bias in favour of some groups and against others. He criticises the sole emphasis on firms as the only type of regional economic actor while neglecting the investor, public sector and the community. He also argues that the references to innovation leave out important theories concerning macroeconomics and class dynamics and as a result, little is said about innovation that is either new or significant. Furthermore, much of the discussion is little more than a debate about how to create collaborators. He also argues that there is a complete lack of attention to the significance of the global reach of finance capital:

''The dogma that 'regions are resurgent' as a result of global transformations implied by the growth of 'informational economies' has almost reached the point of an orthodoxy. But like the fashion for postfordism which preceded it, this represents the triumph of fashion and the influence of academic authority figures over social science. Treating these claims as accounts of the key causal influences on real regional development in general has led the New Regionalists to overlook far more important influences on the economic dynamics of many, and probably most, real world regions'' (Lovering 1999, p. 386).

Lovering uses the example of Wales, a region that has been widely cited by various innovation scholars (Morgan 1997, Cooke 2001), in order to provide evidences for his arguments. He argues that with the exception of the Cardiff area the rest of Wales remains an extremely peripheral part of

the UK with poor performance in all economic indicators. The application of New Regionalism in Wales has had completely misleading effects despite its enormous influence in regional policy making circles. He argues that it has narrowed rather than broadened the intellectual horizons within which explanations are framed, and has been mobilised to narrowed the practical agenda in ways which dovetail with the concerns of vested interests (Lovering 1999).

The argument of the New Regionalism school as to its potential benefits to regions has also been criticised by other scholars. Robinson (2001) gives three reasons as to why little, if anything should be done to assist regions through the new regionalism policies. First, he states that such targeting is an inefficient practice implemented in the name of equity. It is reasoned that directing capital to these areas will thwart economic growth at the national level. Next, he believes that areas lack a competitive advantage due to inherent inferior qualities specific to the region. Third, regional disparities are functionally interpreted. He states that such areas are typically classified according to unemployment and low-income levels. However, socio-cultural conditions can give regions a distinct sense of place, and these qualitative characteristics are difficult to measure objectively. Finally, Robinson (2001) believes that as locational constraints continue to relax with the benefits of new technology the rationale for supporting under-performing regions weakens. In short, places are less important as technology improves and proximity is not necessary for effective communication (however, for an argument about the use of digital spaces and proximity see Komninos 2004).

2.2 Access to finance

It is evident from the literature on regional innovation that although the role of the firm has been seen as critical within the innovation system, the role of firm financing intermediaries has received less analysis despite its recognition as a central actor of the system (Zook 2004). In fact, while there is a strong body of research on the innovation systems and its functionalities, the financing of such systems have received considerably less attention.

The provision of sufficient finance to high growth companies requires the establishment of effective financial systems that support innovation and growth. Public policy has dedicated significant energy to opening regional and global markets for trade, attempting to fill skills gaps, promoting academic science and technology, and developing infrastructure (NESTA 2008b). The provision of finance for high-growth start-ups is a tougher challenge. As the White Paper, New Industry, New Jobs (HM Revenue 2008, p. 14), states:

"access to finance is an important barrier for business to develop their full potential and the government clearly states that any constraint on the ability of UK-based businesses to exercise comparative advantage on the basis of high levels of skills or knowledge must be regarded as a serious impediment to the UK's economic success."

2.2.1 Financing innovation

In the early 1980s, the growing interest in innovation stimulated the academic debate around the role of the firm and technology within the innovation system. In fact such theories placed the firms at the forefront of action. Within traditional neo-classical theory, technology was considered to be exogenous to the economic system but the new evolutionary approach, placed it at the very centre of all economic activities. A main vehicle of technological development, exploitation and diffusion is the firm. The competitive advantage of a nation or even a region is considered to rest increasingly on the innovative performance of firms, and in particular on their capacity to create, diffuse, apply and adapt technological knowledge (Soete and Arundel 1993). Firms do not operate in a blank environment, but within an "innovation system". As Thomas (2000) pointed out, the definition of innovation within the policy discourse has been stretched in recent years in order to encompass a broad business development agenda where all companies, not just high technology firms, can be seen to benefit. "Technology" seen as knowledge in the broadest sense (of products, processes, technologies, markets, management techniques, organisational modes, etc.) becomes fundamental to the competitive survival of firms (Corvers 2000).

However, it is commonly argued that business innovation activities, including R&D, are difficult to finance, and governments around the world have implemented various schemes and interventions which take the form of R&D tax incentives, government R&D expenditure, incentives for collaboration between business and research institutes etc. Several factors make investments in innovation and R&D difficult. Half of the total investments in R&D are mainly allocated to salaries of highly educated scientists and their efforts to create intangible assets, the firm's knowledge base (Hall and Lerner 2010). To the extent that this knowledge is "tacit" rather than codified, it is embedded in the human capital of the firm's employees and is therefore lost if they leave or are fired (Hall and Lerner 2010). A second important feature of R&D investment is the degree of uncertainty associated with its output which tends to be greater at the beginning of a research programme or project (Hall and Lerner 2010).

Public intervention in support of innovation through investment in basic research, yields economically useful knowledge that can be used by firms to develop new product and processes

(Howells 2005). This addresses the classic "market failure" reason for policy intervention in relation to innovation whereby, as Howells (2005) argues, there is an under-investment in R&D and technology because of the existence of uncertainties, externalities and knowledge spill-overs, which create dis-incentives for investments in innovation. Many firms in technologically demanding industries need to combine a variety of technologies in complex ways, and publicly supported research provides an extensive pool of resources from which these firms may draw (Howells 2005). Therefore, there is a need to support investment in knowledge, which would otherwise be under-funded by the private sector (i.e. left to themselves, firms will under-invest in innovative activities because of their inability to appropriate all the benefits arising from these activities), (Musyck and Reid 2007).

Howells (2005) argues that rates of return investments in public R&D remain good, if not excellent. A review undertaken by Scott et al. (2002) noted that attempts to calculate the returns to public research have generally resulted in high rates of return, from 20 percent to 50 percent and higher. Equally, at the regional level, government funding of R&D can benefit regional growth, and Hicks and Lee (1994) found that U.S. federal R&D funding had a statistically significant regional employment effect over the period 1986-88.

Against the argument for public investments in science and technology, a study by the OECD (2003), investigating the relationship between R&D and economic growth over a period 1981-1998, revealed a significant effect of R&D activity on the growth process, across 17 countries. However, it was the business performed R&D that drove the positive association between total R&D intensity and output growth, and not the non-business R&D, performed mainly through public research grants. The OECD indeed found the negative results for public R&D surprising. A possible explanation for the result is that publicly performed R&D may be "crowding out" resources that could be used by the private sector, so that public funded R&D is displacing private investments in science and technology (Guellec and van Pottelsberghe 2000).

Nevertheless, financing R&D through public or private means is an important aspect of regional development and innovation due to the close relationship between R&D and innovation. However innovation is not only a result of R&D expenditure. Innovation is seen as something new, a new product or service in the market. It often comes from research laboratories and institutes but in some cases does not involve R&D at all, e.g. software and internet based companies.

An important tool of promoting innovation and R&D business expenditure is venture capital (Kortum and Lerner 2000). Building on these theoretical premises that put R&D at the forefront of business

innovation but also emphasise the difficulties in financing innovation activities, this thesis concentrates on venture capital investments as a mean of financing R&D and innovation activities. It also elaborates on the public interventions aiming at promoting venture capital investments and investigates the relationship between venture capital and innovation at the regional level. The following sections survey the theories on the role of venture capital in innovation, aiming to address the question of why financing innovation is important and what type of finance can encourage and support innovative business which in turn will foster the innovation system.

2.2.2 Defining venture capital

Venture capital firms are financial intermediaries focused on providing capital to small, fast growth start-up companies that are typically high risk and not amenable to more traditional financing alternatives (Mondher and Sana 2009). A venture capital company usually invests in early stage ventures, while a private equity company targets later stage deals such as expansion financing and MBOs. The distinction between venture capital and private equity is blurred (Manigart and Meuleman 2004). Venture capital professionals are either specialised in a particular industry e.g. biotechnology, or in the absence of such specialisation, commission independent experts to assess the product of the business opportunity. By doing so, venture capital firms reduce the inherent risk that small innovative companies experience. In addition, the way that finance is structured (i.e. the investments is made in funding rounds and not one off investment - staging capital) allows the venture capitalist to gather information and monitor the progress of the firms with maintaining the option to periodically abandon projects (Mondher and Sana 2009). The role of staged funding (i.e. funding rounds) is similar to that of debt in highly leveraged transactions, keeping the owner or manager on a "tight leash" and reducing potential losses from bad decisions (Mondher and Sana 2009). Hall and Lerner (2010) argue that staged capital infusion is the most potent control mechanism a venture capitalist can employ and the shorter the duration of an individual round of financing, the more frequently the venture capital monitors the entrepreneur's progress. They continue by arguing that venture capitalists should invest in firms where asymmetric problems are likely, such as early stage and high technology firms with intangible assets. In fact, Gompers (1995) shows that venture capitalists concentrate their investments in early stage companies and high technology industries.

It is often argued that the value added by experienced venture capital rests not only in its 'hard' financing aspects but also in 'soft' advice and knowledge roles (Kaplan and Stromberg 2001; Pinch and Sunley 2009). Knowledge regarding the target company's industry allows the venture capitalist

to oversee investments more efficiently and more effectively, in part because industry experience enhances the venture capitalist's ability to recognize signs of trouble at an early stage (Sonerson and Stuart 2001). Venture capitalists provide several critical services in addition to providing money such as helping the company to raise more money, reviewing and helping to formulate business strategy, filling in the management team, and introducing the company to potential customers and suppliers (Gorman and Sahlman 1989). Venture capitalists carefully screen firms, structure contracts to strengthen incentives and monitor firms (Kaplan and Stromberg 2001), promote their professionalisation and induce them to behave more aggressively. Gompers and Lerner (2001), argue that venture capital helps entrepreneurial firms to invest more than they would otherwise, grow more quickly, and sustain performance in the long term – even after going public.

The question that arises is why other source of business finance cannot borrow or duplicate such features process of the venture capital industry. Hall and Lerner (2010) summarise these reasons very well:

"Economists have suggested several explanations for the apparent superiority of venture funds in this regard. First, because regulations limit banks' ability to hold shares, at least in the U.S., they cannot freely use equity. Second, banks may not have the necessary skills to evaluate projects with few collateralizable assets and significant uncertainty. Finally, venture funds' high-powered compensation schemes give venture capitalists incentives to monitor firms closely. Banks sponsoring venture funds without high-powered incentives have found it difficult to retain personnel" (Hall and Lerner 2010, p. 34).

2.2.3 Venture capital and the firm

There are three main sources of finance available to business: First, debt finance – most commonly the provision of a loan of some form that is subsequently repaid at a pre-agreed interest rate. These may be available from a High Street Bank or specialist finance providers. There are many sources of debt finance: the corporate bond market for the largest firms; bank financing facilities; small business loans; and small-scale entrepreneurs financing their businesses through re-mortgaging or credit card debt. Second, equity finance – whereby capital is provided to the company in return for a shareholding in the business by corporate investors, Business Angels, venture capital/private equity or public sector schemes. There are a wide range of services provided by the public markets, accessible through flotations or other share issues by the largest firms, through private equity, leveraged buy-outs, management buy-outs and buy-ins. Third, 'soft capital" – typically associated with grant funding or financial subsidies provided from the public sector through grants, R&D tax

incentives, innovation vouchers or other means. Such financial support is typically available through Regional Development Agencies, government departments and devolved administration departments in Scotland and Wales.

The majority of firms accessing finance rely on small-scale debt finance: credit cards, overdrafts and commercial loans (CBR 2008). The high-growth innovative firms often do not fit into this category, especially in their early years. These companies require significant capital up-front, and this is very hard to obtain from conventional sources of debt finance. They tend to have intangible assets, and show a significant delay before generating revenue making than a high risk investment (NESTA 2009). These firms are, of course, some of the most attractive growth prospects, and include startups in the information technology, life sciences and advanced engineering sectors. Innovative, high-growth firms which are essential for the regional innovation system to flourish, need different kinds of support depending on their stage of development. They thrive if there is a smooth progression from one type of funding to the next (CBR 2009). As a result, savings are inadequate and debt finance is inappropriate but venture capital is an alternative form of finance that is structured to address these challenges (NESTA 2007).

Knowledge-based firms have significant intangible assets (e.g. product ideas or inventions that may be protected by patents). They are likely to need funding to cover what may be a lengthy period of negative earnings as they turn these intellectual assets into products in advance of sales. Their lack of tangible assets which could be used as collateral and their uncertain prospects of commercial success mean that they are unlikely to be able to access bank loans. Venture capital is better able to address these challenges on account of its value in screening investment opportunities, providing post-investment monitoring and support and structuring investments because of the equity-based nature of its investments. As a consequence, it is the most important institution supporting technology entrepreneurship (Saxenian and Sabel 2008).

A growing number of critics argue that conventional 'balance sheet' accounting is based on a fiction, namely that the valuations which auditors produce reflect the real value of the firms they audit (Morgan 2004). The over-emphasis on physical assets (land, plant, capital, etc.) and the under-emphasis on intangible assets, transmits totally inappropriate signals to managers, employees, shareholders, and investors (Morgan 2004). However, in the case of venture capital these intangible assets are taken into account during the valuation process of the firm. Venture capital professionals measure the value of the business not solely based on its physical infrastructure, but on the intangible assets that the business may possess such as the calibre of its personnel and its potential

to innovate. To this extent, by contributing to the development of innovative firms, venture capitalists directly contribute to the development of the innovation system.

2.3 The role of venture capital in innovation and regional development

Venture capital cohabits with other players of the innovation system and has positive implications for economic growth. Venture capital investments are mainly made to companies that exhibit strong intangible assets and the potential to grow. The goal of improving intangible assets as basic elements for the innovation process has also gained considerable currency amongst academics concerned with the development of the regional innovation system approach over the last two decades (for example Morgan 2004). As a result, both venture capital and regional innovation scholars share a similar view on the importance of knowledge creation and intangible assets. Investments in innovation and development through learning are seen as essential factors in increasing the innovation capacity of a firm and a region. The role of investors, which has been largely neglected by the regional innovation scholars (Lovering 1999; Zook 2004), is the main focus of this section and more particularly the important role that venture capital plays within the regional innovation system (Saxenian and Sabel 2008).

Venture capital's importance in regional and national economic development is mainly based on U.S. evidence of its role in encouraging innovation by funding the emergence and growth of new technology-based companies. This section, reviews the joint literature of these two theoretical frameworks, venture capital and regional innovation, and it is concerned with the role that venture capital plays within the regional innovation system.

The role of venture capital in economic development increasingly is recognised as central to the development of an entrepreneurial economy (Mason and Harrison 2002a) and venture capital firms have become a key component of the innovation process (Powell et al. 2002). There is an emerging consensus that venture capital is a key component of "new economy innovation systems" formed by highly dynamic sets of interrelationships between VCs, market conditions and new firm incubators (Cooke 2001; Rosenberg 2002; Pinch and Sunley 2009)

On the basis of his study of the Internet industry in the US, for example, Zook (2005, p. 6) concludes that: *"Financial institutions of innovation are probably more important for economic growth in this knowledge economy than the location of research universities.*"

Kenney and Florida (2000) argue that VCs play a key role within regional innovation networks by providing their investee firms with 'smart money' – combining both money with non-monetary inputs and especially technological and business knowledge VCs act as catalysts or 'technological gatekeepers' who facilitate and direct innovations within localised clusters.

Zook (2000) argues that crucial to the operation of the regional financing system are the feedback loops that emerge over time as venture capitalists, entrepreneurs and labour come together in various new ventures. These new or strengthened connections within a regional system provide the basis for subsequent efforts to form innovative firms. If the new firms are successful, there are an additional number of valuable feedback mechanisms that emerge. The most basic result, the generation of new wealth, can give an added surge to the investing process. However,

"more important than the actual money, is the reputation and prestige that comes with it. This success allows institutionalized venture capital to successfully raise future venture rounds and allows some entrepreneurs the opportunity to change their role in the system, either as angel or as a partner with a venture capital firm. It is through this process of information exchange, investment and feedback that a region's venture capital system develops and matures'' (Zook 2000, p. 3).

Analysis of the significance of venture capital in innovation and economic development is available at four levels: i) company growth, ii) creation of new industries; iii) networking and clustering iv) patents and R&D expenditure.

2.3.1 Venture capital and company growth

In 2007, IE Consulting and BVCA (2007) conducted a survey of over 1,000 risk capital company recipients. The analysis of their responses saw that over the five-year period to 2006/7, venture firms in the sample increased their worldwide employment by 8 per cent p.a., a much higher rate of growth than FTSE Mid-250 companies (at 3 per cent p.a.). Their UK employment also grew by 6 per cent, compared to a national rise in employment of 1 per cent p.a. Equally, exports in venture-backed companies grew by 14 percent a year, compared with a national average of 4 percent.

The evidence from the US, where venture activity has a longer pedigree, is even more compelling. Puri and Zarutskie (2008), suggests that the amount of employment generated by VC backed firms accounted for nearly 10 percent of employment in the US in the late 1990s and early 2000s, steadily rising from about 5 percent in the 1980s. A study undertaken in the US by Global Insights and NVCA (2007), revealed that U.S. companies that received venture capital from 1970-2006 accounted for 10.4 million jobs and $2.3 trillion in revenues in 2006. The total revenue of venture capital-financed

companies comprised 17.6 percent of the nation's GDP and 9.1 percent of U.S. private sector employment in 2006. Venture capital-backed companies outperformed their non-ventured counterparts in job creation and revenue growth. Employment in venture-backed companies jumped by 3.6 percent, while national employment grew by just 1.4 percent, between 2003 and 2006. At the same time, venture capital-backed company sales grew by more than 11.8 per cent, compared to an overall rise in U.S. company sales of 6.5 per cent during the same period.

2.3.2 Creation of new industries

Creating new industries requires sustained investment over the long-term, continued commitment and long term resources. The semiconductor and microcomputer industries are good examples of this lengthy and capital-intensive process. In both cases, it took up to ten years of continued risk capital investing before the industries properly took off and virtually every other new industry since have followed this pattern (Bygrave and Timmons 1992).

In the words of Bygrave and Timmons (1992, p. 2), their effects have included *"the creation of hundreds of thousands of new jobs, new expenditures for research and development, increased export sales, and the payment of hundreds of millions of dollars in state taxes. By mobilizing and later recycling scarce risk capital and entrepreneurial talent, venture capital firms have transformed the economy*".

Venture capital has played a unique role in the information and commercialisation of entire new industries (Bygrave and Timmons 1992; Mason and Harrison 2002) personal computers, cellular communication, microcomputer software, biotechnology , and overnight delivery. In recent days, venture capital became a major source for finance in cutting edge industries such as healthcare and internet firms. This underline's Zook's (2000) observation about the high positive correlation between internet firms and venture capitalists in the US. In the case of biotechnology, *"it is safe to say that without venture capital and regional agglomeration, the industry would not exist in the form that it does today*" (Powell et al. 2002, p.304).

Zook (2004) has analysed how the spatial structure of knowledge used by venture capitalists during the development of the internet industry contributed to its clustering. He argues that "*venture capital are best understood as tacit information brokers who acquire and create tacit knowledge about industries, market conditions, entrepreneurs and companies through a constant process of Marshallian interaction and observation*" (Zook 2004, p. 628).

2.3.3 Networking and clustering

Private intermediaries like venture capitalists, management accountants, specialised law firms and consultants cohabit the same place, facilitating systemic interactions (as shown for Silicon Valley in Saxonian 2008). Norton (2000) explores the importance of geographical proximity for entrepreneurial innovation and concluded that 'new economy' places are characterized by the geographical concatenation of scientists, engineers, entrepreneurs and venture capitalists looking for value from technological discontinuities: the more disruptive, hence rare, the better. Cooke et al. (2002) argue that VC managers recognize certain areas in which their companies can operate more effectively by trading with each other rather than staying with an established supplier. These companies operate as a mini-cluster, something that is in the interests of the firms and the venture capitalist seeking to enhance his investment. It also fits in with regional economic development policy which advocates supply chain clusters in target industries (Cooke et al. 2002).

The advantage of location is very much based on access and information and increasing returns are present in the form of overlapping networks, recombinant projects, personal and professional relationships, and interpersonal trust and reputation, all of which are thickened over time (Powell et al. 2002). Thus,

"venture capital is itself a powerful search network: investors support a diverse portfolio of entrepreneurial experiments and combine hands-on monitoring and mentoring with market selection; this institutionalizes a continuous and rigorous process of new market identification, selection, replication , and adaptation, as well as learning and the accumulation of knowledge" (Saxenian and Sabel 2008, p. 3).

2.3.4 Patents and business R&D expenditure

A variety of studies suggest that venture-backed firms are responsible for a disproportionate number of patents and new technologies (Kortum and Lerner 2000), and they seem to bring more radical innovations to market faster than lower growth businesses that rely on other types of finance (Gompers and Lerner 2001). More particularly, Kortum and Lerner (2000) examined the influence of venture capital on patented inventions in the United States across twenty industries over three decades. They found that increases in venture capital activity in an industry are associated with significantly higher patenting rates. While the ratio of venture capital to R&D averaged less than 3 percent from 1983-92, they estimated that venture capital may have accounted for 8 percent of industrial innovations in that period. The strong relationship between venture capital and patenting on an industry level is also indicative of a relationship between venture disbursements and

innovative output. Kortum and Lerner (2000) also examined the possibility of venture capital firms being more keen to patent inventions compared with no venture capital backed firms due to mainly two reasons: venture backed firms may fear that the venture investors will exploit their ideas and investors are keener to invest in companies with patents already granted. In order to address these issues, the researchers examined three additional measures of innovation activity: i) number of patent citations and the economic importance of a patent; ii) frequency and extent of patent; and iii) trade secret litigation in which firm has engaged. All the tests of differences in means and medians in these three categories are significant at least at the five-percent confidence level, as well as when they employed regression specifications. Given the rapid increase in venture funding since 1992 in the US, the report suggested that by 1998 venture funding accounted for about 14 percent of U.S. innovative activity.

Mann (2005) reports qualitative work (a series of interviews of venture capitalists, lenders and executives at software start-ups and large software firms) suggesting that patents have a variety of potential positive effects. Mann and Sager (2007) have also analysed the relation between the patenting behaviour of start-up firms and the progress of those firms through the venture capital cycle. Linking the data relating to venture capital financing of software start-up firms with data concerning the patents obtained by those firms, they found a significant and robust positive correlation between patenting and several variables measuring the firm's performance (including number of rounds, total investment, exit status, receipt of late stage financing and longevity).

It is important to highlight that most of the studies above demonstrate a significant and highly positive association between venture capital and innovation rather than direct causality. This thesis expands on the existing literature on the relationship between venture capital and patenting by including an additional parameter in this relationship, which is the source of venture capital (public or private). As such, the thesis responds to the gap in the literature discussed above, by analysing the relation between patenting practices of VC backed firms paying particular attention to two aspects: first, their acquisition of venture finance and progress through the venture capital journey, and second, the relationship between patent practices and the source of VC finance.

2.4 The regional dimension of the venture capital industry

The new economic geography has attracted particular attention by various scholars (e.g. see Martin 1999), however, there has been much less progress in understanding the spatial characteristics of venture capital or its role in local and regional development (Mason and Harrison 1999). This thesis aims to reveal new characteristics of the venture capital communities in regions and to contribute to

the debate about regional dimension of the venture capital industry and its role in regional development. The thesis therefore seeks to explore whether geography is still important for interactions for VC professionals and how it may differ between regions led by publicly provided VC systems and those led by private ones.

The importance of interaction and proximity between VC funds and businesses has been highlighted by Zook (2004) who argues that venture capitalists' ability to assist successful Internet firms was dependent upon largely regional systems of personal contacts and networks (know-who) through which difficult to acquire knowledge about technology, companies, strategies and markets (know-how) was created and quickly exchanged. Proximity is often a central factor because of the largely tacit nature of the knowledge used by venture capitalists (Zook 2004). The importance of networks in generating investment opportunities affects the spatial distribution of investment activity because social relations tend to cluster in both geographic and social spaces (Sorenson and Stuart 2001). Experienced venture capitalists have abundant contacts and deep knowledge of particular industries; thus, referrals to relevant sources of expertise are another important resource they provide and this social network is also more readily tapped into when firms are geographically proximate (Powell et al. 2002).

Inter-firm relationships in the venture capital community effectively reduce spatial limitations on the flow of information. In their analysis Sorenson and Stuart (2001) focus on how the network connecting the members of the VC community – built up through the industry's widespread use of syndicated investing – facilitates the diffusion of information across spatial boundaries, thereby decreasing the space-based constraints on economic exchange.

The role of spatial proximity in the diffusion of knowledge and construction of social networks has also been praised by Zook (2004). At least two dimensions of a venture capitalist's contact network can tribute to the localization of investments by influencing the venture capitalist's ability to appraise investment opportunities under asymmetric information. First, individuals have greater confidence in information collected from trusted parties. Consistent with this disposition, reports on the VC industry indicate that venture capitalists repeatedly finance investments that they learn about through referrals from close contacts, including entrepreneurs that the capitalist previously financed, fellow venture capitalists, family members, or friends (Fried and Hisrich 1994). These individuals have an interest in conveying accurate information and bringing high-quality investment opportunities to the attention of the venture capitalist because they typically wish to maintain an ongoing relationship with the venture capitalist. Second, lacking a strong tie, multiple and

corresponding sources of information might offer the venture capitalist some assurance regarding the quality of a potential investment (Sorenson and Stuart 2001).

Powell et al. (2002) investigating the spatial concentration of ideas and money in the biotech sector, found that both research-intensive biotech firms and venture capital firms that fund biotech are highly clustered in a handful of key US regions. They also argued that the importance of tacit knowledge, face-to-face contact and the ability to learn and manage across multiple projects are critical reasons for the continuing importance of geographic propinquity in biotech.

Despite the incentives for choosing from a broad array of opportunities, various scholars argue that venture capitalists continue to exhibit highly localized investment patterns in both physical and industry space (Gupta and Sapienza 1992; Norton and Tenenbaum 1993, Sorenson and Stuarts 2001). Some more recent studies reveal that the importance of localisation may have declined to some extent. For example, Wiltbank (2009) found that Business Angels are now prepared to invest even within 250km, and a quarter of them were also prepared to invest outside the UK.

It is now well established that venture capital is not equally available in all parts of a country (Florida and Kenney 1998; Florida and Smith 1991, 1992; Mason and Harrison 2002a; Zook 2002; Martin et al. 2005; Schwartz and Bar-el 2007). In the USA venture capital investments are highly concentrated at all spatial scales: regional, state and metropolitan areas. The pattern at the regional scale is bi-coastal, with venture capital investing concentrated in California, New England and New York. At the metropolitan area scale San Francisco, Boston and New York account for the majority of all investments (NESTA 2011). The geographical distribution of venture capital investing in the UK favours London and the South East (Mason and Harrison 2002a; Mason 2007). Because of the dominance of MBO investments in the UK there is a much weaker relationship between venture capital investing and high-tech clusters (Martin et al. 2002). However, early stage investments continue to be disproportionately concentrated in London, the South East and Eastern regions and are more closely linked to high-tech clusters (such as Cambridge) and more generally to the locational distribution of high-tech firms (Mason and Harrison, 2002). In contrast, there is greater dispersal of venture capital investment in Germany. Munich is the biggest single host to venture capital firms but accounts for less than 20 per cent of the total (Fritsch and Schilder, 2006). In total, six cities account for 65 per cent of venture capital firms: nevertheless, all of them are major banking and financial centres (Martin et al. 2005).

Various scholars suggest that substantial differences exist between regions' venture capital institutions; especially their ability to produce and use tacit knowledge (Zook 2004). Cooke et al.

(2003) observed a close relationship between venture capital activity and regional innovation systems. He pointed out that less innovative US regions (compared with California, Massachusetts and Texas) also tend to rely more upon public venture capital and enterprise support, and regional innovation systems here are both rare and newly discovered. Advanced regions are dependent on public research funds for basic scientific investigation, but exploitation and commercialisation of scientific findings is looked after by private bodies (Cooke et al. 2001). This include venture capitalists, corporate venturing of larger firms, contracts and milestone payments by big pharmaceutical, media or ICT firms, Business Angels, patent lawyers, specialist corporate lawyers, merchant banks, consultants and management accountants (Cooke et al. 2001).

Table 1: Aspects of regional and private innovation systems

Regional innovation system (RIS)	Private system of innovation (PSI)
Research & development driven	Venture capital driven
User-producer relations	Serial start-ups
Technology-focused	Market-focused
Incremental innovation	Incremental & disruptive
Bank borrowing	Initial public offerings
External supply-chain networks	Internal EcoNets
Science park	Incubators

Source: Cooke et al. 2001

The geography of venture capital investing closely relates to the locations of high-tech clusters (Florida and Kenney, 1988a; 1988b; Florida and Smith, 1991; 1992). The role and importance of cluster in regional innovation has been examined in previous sections. The availability of venture capital funds is argued to have been central not only in terms of providing risk capital but also in supplying a vital co-ordinating mechanism (see Langlois and Roberston 1995). In Europe however, the argument is that there is a lack of geographical clustering and existing cluster lack the critical mass to generate the mutually enforcing networking synergies and venture capitalists that are needed to give such cluster the strong growth dynamic found in US examples (Martin et al 2001). Linked to this argument is the debate on the role of venture capital in clusters formation and more particularly the two contrasting views on the clustering or the dispersion of venture capital investments. More particularly, policy initiatives on venture capital often contradict the clustering approaches. Martin et al. (2001) for example note:

"such arguments tend to run counter to the other view, also found in official policy circles, that instead of lacking spatial concentration venture capitalism is already too geographically localised, being disproportionately located in, and orientated to, more dynamic and buoyant region to the detriment of less prosperous areas which as a consequence face a "risk capital gap. According to this argument there should be greater regional dispersal of venture capital funds to less developed and economically lagging regions so as to stimulate and support new ad small firms activity – especially innovation activity – in such areas" (p.15).

Thus under the clustering view, the supply of venture capital is too fragmented geographically and should be more spatially concentrated in the regions that are leading high-technology development; while under the dispersion view the supply of venture capital tends to be too biased towards a few selected areas at the expense of unmet demand in other regions (Martin et al. 2001)

The lack of venture-based high technology in many regions is to a substantial degree a reflection of regionally uneven economic structures so that the problem many regions face goes far deeper than merely venture financing i.e. there is implicitly a lack of private sector demand.

Martin et al. (2001) suggest that the promotion of a more even geographical spread of venture capitalism – the dispersal argument – is not only likely to be difficult, but of itself will not automatically stimulate the development of local high-technology activity. The supply of venture capital – whether spatially concentrate or dispersed – will not automatically create its own high-tech demand. The debate on the supply and demand side has important implication in the VC policy which is mainly based on the implicit assumption that government intervention is intended to act as a stimulant to demand and signal to the private sector that there is latent demand in a region.

2.4.1 The demand and supply side argument

The supply side approach which emphasises the creation of firms, jobs and wealth based on internal resources, is a part – albeit an important part – of the development process (Sweeney 1987; cited by Malecki 1991). The debate on the supply and demand side of finance for companies, especially SMEs has received attention by various scholars (Mason and Harrison 2002, Martin et al. 2005). In the UK there is a perception that there is a mismatch between the demand and supply of investment especially at the seed and early stage market. Companies often complain that they cannot secure external finance, while investors argue that the problem is that there are not enough valuable opportunities to invest. This perceived mismatch between demand and supply of capital, it is argued, has created several gaps in the financing chain, what is often called "equity gaps".

The development of the venture capital market itself has often been viewed as a potential solution to the small-firm funding gap, namely by providing risk capital or equity to enterprises that find it difficult (or prefer not) to raise medium-term to long- term finance either from banks or from the normal capital markets (Martin et al. 2005). However, even within the venture capital market, there are concerns that the equity gap persists.

In fact, the question on whether an equity gap truly exists is notoriously difficult to answer (for a discussion see Martin et al. 2005). Such a gap may exist in specific business development stages or industries and the debate on whether such gaps exist at the regional level has recently received particular attention from several economic geography scholars (Mason and Harrison 2002 and Martin et al. 2005). A common conclusion amongst these scholars is that there is an uneven geography of venture capital investments. At the European level, there has been a concern that less prosperous areas in Europe are particularly disadvantaged when it comes to venture capital backed new enterprise development. According to this view, venture capital funds are vital to economically lagging regions in order to stimulate and support new and small-firm activity especially innovative activity in such areas (Martin et al. 2005, p. 1209)

On the one hand, policy makers often argue that there is a shortage of young innovative companies in less prosperous regions and this is partly attributed to the undersupply of risk finance in these regions. They also believe that there is distortion of the market due to overconcentration of venture capital activity in more prosperous regions. On the other hand, venture capital fund managers argue that *"the venture capital market operates efficiently because venture capitalists will make an investment if the potential return is higher than their assessment of alternative proposals for a given level of risk"* (Queen 2002, p2). As a result, it is argued that, venture capital investments are fewer in some less prosperous regions only because these regions are home to fewer investable opportunities. This debate is nicely captured by Martin et al. 2005:

"are 'regional gaps' merely the geographical expressions of other gaps (for example, gaps in the new start-up or new high-tech venture sectors of the market) that arise because of regional differences in economic, industrial, and business structure? Or are there explicit spatial biases in the operation of the venture capital market that give rise to an inherent regional dimension to equity gaps?" (p. 1209).

In order to provide some light into these issues, Martin et al. (2005) analysed the responses to a survey from venture capital professionals in the UK and Germany. The survey results saw that "*the*

lack of proposals with prospects of decent returns" is the most prominent constraint in the UK and second most important in Germany.

Mason and Harrison (2003b) identified three aspects to demand side constraints: first the population of business capable of generating the returns that are sought by venture capital investors is relatively small in the UK and that given the regional variations in business start-ups and growth, in some regions the demand for venture capital will be particularly low. Second, entrepreneurs either forgo significant growth in order to retain 100 percent ownership of their business or else they seek to grow on the basis of either insufficient finance or inappropriate forms of finance often with disastrous consequences. Third, a significant proportion of the SMEs which put themselves forward as candidates for equity capital are unsuccessful in raising venture capital because they are not investment ready.

2.4.2 Policy responses to the equity gap

Government schemes in support of the VC industry have been seen as a response to the belief that there are significant funding gaps, particularly for small high-technology start-ups (Sunley et al. 2005) or in particular regions (Mason and Harrison 2002a). Such publicly backed schemes help in leveraging private money (Lerner 2002), stimulating regional entrepreneurial activity (Mason and Harrison 1999) and generating R&D spill overs (Lerner 2002). Venture capital is no longer a sole activity of private players, but various public bodies of the innovation system are now actively involved in venture capital activities as a result of a number of schemes implemented by the governments around the world. Public venture capital initiates are defined as ''*programs that make equity or equity-like investments in young firms, or encourage other intermediaries to make such investments''* (Lerner 2002, p. 2). The UK policy response to the "equity gap" has often included a regional perspective. As Sunley et al. (2005, p. 257) observe:

''*the addition of a regional dimension is usually justified in two ways. First, policy-makers often point to the potential efficiency benefits arising from a regional method. They suggest that venture capital programmes work best when they are regionally constructed and operated because this facilitates closer relations between investors, investees and supporting specialist firms. The programmes can thereby better respond to specific regional conditions and problems.*''

Murray (1998) has also provided justifications for regionalizing venture capital centres on the need to address regional equity gaps and market failures that may exist in particular regions. Indeed, *"policy-makers view venture capital as playing a central role in both innovation policy – facilitating*

the commercialisation the science base – and entrepreneurship policy - facilitating the emergence of high growth businesses - and so will intervene to address gaps in its supply" (Murray 2007, p. 174).

The inclusion of a regional dimension in the government schemes is also based on the importance of proximity and local networks. As Zook (2000) puts it: *''the close integration of venture capital with the historical development of a region's industry emphasizes the importance of local networks to the venture capital investment process. These systems of venture capital are very dynamic and, as demonstrated with the internet industry, are capable of evolving with market opportunities. It is likely that this ability to adapt to the changing dynamics of the economy will prove even more important in the future as regions attempt to reinvent their economies, enter new industries and innovate''* (Zook 2000, p. 23).

In the UK, venture capital funds have been established by consecutive governments with (sometimes) implied objectives to increase innovation and regional development. The aim of these funds has been very well summarised in a phrase of the Head of Small Business service, DTI, "*we are setting a floor on what the private sector will risk*" (Cambell 2000, cited by Mason and Harrison 2003). It becomes obvious from the literature that ''access to finance'' is only one part of the support package and public funds aim to equip firms with greater capacity, laying the ground work in the hope that private funds will come in and wider tacit knowledge be brokered.

Regional Venture Capital Funds for example, were intended to address market weaknesses in the availability of finance for small and medium sized enterprises (SMEs) by stimulating the supply of new sources of finance. This was intended to ensure that each region (in England) has access to regional based VC funds and demonstrating that investors in early stage funds can make robust returns, thereby promoting the private sector venture capital industry (Mason and Harrison 2003). Regional Venture Capital funds (RVCFs) had the following objectives: To increase the amount of equity finance available to growing SMEs to enable them to realise their full potential; to ensure that each English region has access to at least one viable regionally based venture capital fund making equity –based investments in smaller amounts; to demonstrate to potential investors in early stage venture capital funds that robust returns can be made by funds investing in the equity gap, thereby promoting the private sector venture capital industry (DTI 1999, cited by Mason & Harrison 2003).

The government's intention was that ultimately the public sector will be able to withdraw its support form the funds having demonstrated the viability of early stage venture capital investing, leaving the private sector to invest in such funds without further support (Mason and Harrison 2003). A global study undertaken by Brander et al. (2010) provides significant evidence on the role of government

VC in stimulating innovation. The researchers analysed over 28,800 enterprises based on 126 different countries that received venture capital funding in the 2000-2008 period. The enterprises cover a wide range of industries but were dominated by high-tech firms. The performance of enterprises financed by some form of government venture capital was compared with those supported by private venture capitalists in order to determine the impact of public involvement on performance. The key findings of the study was that enterprises with moderate government venture capital support, outperform enterprises with only private venture capital support and those with extensive government venture capital support, both in terms of value creation and patent creation (Brander et al. 2010). However, such publicly backed schemes have been criticised in the UK for their sole focus on the supply side, ignoring demand side constraints. As Martin et al. (2001) note:

"in practice of course , the geographical location of venture capital investment is the outcome of a complex interaction of demand and supply processes. To some extent the concentration of venture capital funds in high-growth regions is demand-induced and thus venture capitalism can be expected to follow and thus accentuate the geography of uneven economic development" (Martin et al. 2001, p. 17).

As a result, a spatial bias is likely to be built into the supply of venture finance, and due to the role of proximity and face to face contacts in venture capital investing, it will tend to favour enterprises located close to venture capital institutions (Martin et al. 2002). According to Martin et al. (2002): "a *strong mutually reinforcing process seems to be at work: venture capital firms emerge and develop where there is a high level of SMEs - and especially innovative SME – activity, and this in turn stimulate further expansion of the local venture capital market which in turn contributes yet further to the formation and development of local SMEs and so on"* (p. 18).

Mason and Harrison (2003, p. 864) conclude that "*the clear implication is that simply creating pools of venture capital will not, of itself, lead to an increase in the amount of early stage venture capital that is invested. Indeed, the likely effect of creating an additional supply of early stage venture capital, operating on a less than fully commercial basis as a result of government financial support, in a situation in which there is a restricted supply of viable, high potential businesses, will be to create distortion in the Market which over longer term could drive out existing private sector investors. A supply side approach is therefore insufficient to solve the equity gap. The proposal to support regional venture capital funds requires to be complemented by initiatives that address these demand-side constraints*."

2.4.3 Venture capitalists skills in public sector funds

The competence of the venture capitalist investment managers arises from active business involvement in the respective industry. It cannot be acquired in short order, nor is it easily transferable (Kanniainen and Keuschnigg 2004). Gompers and Lerner (1999, p. 4) note that: ''*not only is it difficult to raise a new venture capital fund without a track record, but the skills needed for successful venture capital investing are difficult and time-consuming to acquire*". Therefore Kanniainen and Keuschnigg (2004) argue, it is expected that the limited supply of informed VCs, rather than the availability of financial capital, is the scarce factor in launching innovative firms.

This has direct implications for the creation and management of the publicly backed funds. Despite their commitment to act as commercial funds, various scholars (Mason and Harrison 2003; Kanniainen and Keuschnigg 2004; Shäfer and Shilder 2009) have found there to be a lack of venture-capital skills to enable effective fund management.

As Mason and Harrison (2003) point out, venture capitalist competence is based on experience - classic venture capitalists cannot be hired straight out of MBA courses or consulting firms, so there is a limited scope for quickly increasing the supply of classic venture capital skills. Moreover in the case of publicly backed funds,

"experienced venture capitalists with classic investing skills are unlikely to be attracted to the Regional Enterprise Funds because of this unattractive level of remuneration. In this circumstances and given that there is a considerable degree of political capital invested in this initiative, there is a risk that fund managers will be appointed whose competence is predominantly in financial engineering and who have little ability to provide these value-added skills to support young growing firms, or even to identify promising new and early stage ventures" (Mason and Harrison 2003, p.865).

This argument is also supported by the work of Shäfer and Shilder (2009) in the case of Germany which suggests that public sector venture capital funds may not be as 'smart' as private sector venture capital in terms of adding value. The capabilities of public sector fund managers are therefore often questioned, both in terms of their ability to make good investments (quality of deal flow, domain knowledge, effectiveness of their due diligence) and to add value to their investee companies (e.g. mentoring skills, strategic insights, networks) (see NESTA 2009). According to Munary and Toschi (2010), even if the public intervention was targeted to companies with a real need for government aid, this financial support could be inefficiently managed by local VCs due to their lack of experience and skills. On the other hand, examining the case of Southampton, Pinch and

Sunley (2009) suggest that the ability of private sector venture capitalists to add value may be exaggerated.

Pissarides (1999), has observed in the case of the European Bank for Reconstruction and Development's (EBRD) SMEs support funds that a crucial element in these type of funds is the experience of the fund managers…"*the main reason why a few funds are not performing satisfactorily is that they lack expertise"* (Pissarides 1999, p. 530).

There are two additional factors that are directly related to the skills of venture capitalists operating in publicly backed funds. First, such funds have multiple objectives: "*explicit non-financial objectives also make it harder to recruit an appropriate team: investment professionals with the skills to undertake economic development work are rarely those with the best track records of backing and developing profitable companies''* (NESTA 2008a, p. 19). The second factor is related to the investment strategies adopted by such funds. For example, Allen (2001, cited in Mason and Harrison 2003) notes that one consequence of the investment of public monies in the funds, and the consequent need for fund managers to be accountable for the use to which it is put, will be to encourage even more risk averse behaviour with the result that there will be less likelihood of investment at seed stage (p. 86).

However, the route of the problem may also lie in the way that public funds are established. The fact that fund managers with previous experience in running public funds are also selected to run newly established funds if of great concern according to Mason and Harrison (2003), since the credentials of these fund managers are derived from their long experience in regional public sector venture capital (e.g. WM Enterprise and Yorkshire Enterprise). This certainly does not necessarily imply that these fund managers will not be able to manage the funds; however, it does raise questions whether they can bring fresh thinking to the activities of these funds (Mason and Harrison 2003, p. 862).

The more limited skills of public venture capitalists may also be related to the fact that regions outside the core venture capital centres of London and South East often lack the pool of people with the necessary skills to effectively run the funds. As Mason and Harrison (2003) point out, experienced VCs with sophisticated investing skills and wide relational networks are more likely to be located in economically advanced regions, due to the spatial concentration of VC activity.

In general, the relationship between the venture capital industry and regional coverage and institutions of governance has been mainly explored from the point of the government's role (and the need) in supporting the industry (see Lerner 2002, 2009; Murray 2007). Although the demand

side is an important part of the argument, in this research the focus is given to the supply side for two main reasons. First, government schemes are mainly intended to close the gaps in the supply of venture capital at both the national and regional levels Second, there has been limited research in the supply side of VC at the regional level (see Mason and Harrison 2003). Therefore this thesis bypasses many of the public policy questions that those controversies entail, and instead focuses on the supply of finance through VC.

This thesis thus aims to examine whether the introduction of the publicly backed funds in the UK supports the relationship observed by Cooke et al. (2003) between public venture capital and regional innovation in the US, i.e. that less innovative regions also tend to rely on public venture capital in the UK. This thesis will thus seek to examine this question: *Do publicly oriented regional innovation systems also attract publicly backed venture capital funds in the UK, and if yes, what does this mean for the regional innovation system?*

2.5 Venture capital, interactions and proximity

The role played by geography and spatial proximity in structuring interaction between different bodies of the regional innovation system has long interested economic geographers and sociologists. Morgan (1992,2004) highlights the importance of local linkages and tacit knowledge, trust and the development of interegional networks and organisation proximity. As mentioned earlier, these particular attributes are also found in venture capital community. Trust, tacit knowledge and personal interaction are necessary elements of a successful VC community. This section reviews the literature concerned with the importance of the networks of interactions within the venture capital community and identifies gaps that this thesis aims to fill.

2.5.1 Information asymmetries

Potential investors face major difficulties in realising the potential of an investment in R&D mainly due to what it is widely called “asymmetric information” between entrepreneur and investor (Sorenson and Stuart 2001). Several scholars on venture capital note that information asymmetries play an important role in venture identification and finance (Lerner 1994, 1995; Gompers 1995, Sorenson and Stuart 2001; Mondher and Sana 2009). The venture capital industry is characterized by great uncertainty about returns and information asymmetries between principals and agents (Mondher and Sana 2009). Venture capital investments entail higher intensities of uncertainty and in general higher intangible assets (Gompers 1995). Sapienza and Gupta (1994) argue that as the task

uncertainty - defined as the difference between information required to perform a task and the information already possessed – facing the managers of a venture increases, the information-processing capacity of the VC-CEO decision-making unit must increase to facilitate joint decision making. They suggest that the magnitude of task uncertainty is a function of the state of a venture's development and the degree of innovation it is pursuing.

In the innovation setting, the asymmetric information problem refers to the fact that an inventor frequently has better information about the likelihood of success and the nature of the contemplated innovation project than potential investors (Hall and Lerner 2010). As Sorenson and Stuart (2001, p. 1552) put it, *"information asymmetries exist because entrepreneurs know more than venture capitalists about the opportunities they seek funding to pursue and venture capitalists cannot simply rely upon entrepreneurs for accurate information about the quality of their business plans".* Investors have great difficulty in distinguishing good business opportunities from bad, and the entrepreneur is reluctant to reduce these information asymmetries by revealing more information to potential competitors.

Venture capital firms, address the problem of information asymmetries by scrutinising the business proposal through a lengthy due diligence process. Multiple and corresponding sources of information might offer the venture capitalist some assurance regarding the quality of a potential investment (Sorenson and Stuart 2001). In the absence of public sources of information about early stage companies, personal and professional relationships provide one of the primary vehicles for disseminating timely and reliable information about promising new ventures (Sorenson and Stuart 2001).

Sorenson and Stuart (2001) investigated patterns of exchange in the U.S. venture capital industry from 1986-1998 and empirically demonstrated that the social networks in the VC community—built up through the industry's extensive use of syndicated investing—diffuse information across boundaries and therefore expand the spatial radius of exchange. Venture capitalists that build axial positions in the industry's co-investment network invest more frequently in spatially distant companies (Sorenson and Stuart 2001). Sapienza and Amason (1993) also found that the pursuit of greater technological innovation is associated with greater openness in venture capitalists – entrepreneurs relationships especially for ventures that have overcome some of the liabilities of newness.

2.5.2 Interaction as a mean of minimising asymmetries

Innovation is an interactive process between the firms and the basic science infrastructure, between different functions within the firm, between produces and uses at the inter-firm level and between firms and their wider institutional milieu (Morgan 1997). Interaction is a significant element of the venture capital industry and it is essential in all aspects of its activity, from the business proposal identification to the final exit through floatation or trade sale. In such a milieu, access to reliable information about new opportunities occurs through personal and professional networks, and these ties are critical in reducing uncertainty about projects that are not well understood by non-experts, exceedingly risky in terms of their payoff and unclear in terms of their eventual market impact (Powell et al. 2002). In the venture capital market some venture capitalists presumably have better-quality relationships and enjoy more influential network positions than others, implying differences in clout, investment opportunity sets and access to information (Hochberg et al. 2007).

As the industry amasses ever larger pools of capital to dispense, venture capitalists expand their influence in determining who receives funding to pursue their entrepreneurial visions and to that extent these spells of entrepreneurship affect socioeconomic trajectories, venture capitalists become agents for social stratification (Sorenson and Stuart 2001). Personal relationships and networks between scientists, entrepreneurs and VCs are crucial to the growth of high technology clusters, as they act as channels for knowledge dissemination (Powell et al. 2002).

Existing literature is mainly concerned with the interactions between the investor and the investee company providing information on the particular characteristics of these interactions – before and after the investment - and their potential benefits to both investors and investee companies. While the literature documents the prevalence of networks in many financial markets, the performance consequences of the venture capital community organisational structure remain largely unknown (Hochberg et al. 2007). There is some theoretical evidence to support the argument that interaction and networking is important for the venture capital industry. Interactions can attribute towards pre-investment and post-investment knowledge exchange (Sorenson and Stuart 2001) and are more important at the early stage of the investment (Bygrave and Timmons 1992; Sapienza and Amason 1993; Pinch and Sunley 2009).

Pre-investment knowledge exchange includes identifying suitable opportunities by mobilising a wide network of contacts, assessing market trends and general macroeconomic factors. Because each of these tasks becomes increasingly difficult at a distance, even passive investors – those who invest

without intending to play an active role in managing the new venture – will likely invest locally (Sorenson and Stuart 2001).

After investing in a start-up, venture capitalists perform two important functions. First, they monitor their investments. Because venture capitalists make substantial investments in young companies with managers whose interests may conflict with the venture capitalists' objectives, venture capitalists actively monitor their investments to mitigate agency problems (Sorenson and Stuart 2001). A substantial body of (primarily theoretical) work in corporate finance concerns the optimal design of contracts between venture capitalists and target companies to attenuate the agency problems inherent in providing capital to new ventures (for a review, see Kaplan and Stromberg 2001). Several aspects of the contracts between venture capitalists and the entrepreneurs they fund, such as staged financing (Gompers 1995; Bergemann and Hege 1998) and the allocation of control rights (Hellman 1998), help mitigate this concern. Although these contracts reduce the need for monitoring, they do not eliminate it. Thus, monitoring the managers of their portfolio companies remains an important post-investment activity for the venture capitalist (Sorenson and Stuart 2001).

Once the investment is made, venture capitalists make their most important contributions in the earliest stages of new ventures (Bygrave and Timmons1992) and therefore the amount and style of interactions between venture capitalists and entrepreneurs is different in earlier stage ventures than in later stage ventures (Sapienza and Amason 1993). During the post-investment period, venture capital professionals provide added value services (Sorenson and Stuart 2001) by monitoring closely their portfolio company, search for clients for the company, acquire a deep knowledge of the product, assess marketing, operational and financial strategies, seek to identify co-investors for further investment rounds, potential ways of exits. In order to facility post-investment knowledge exchange, venture capitalists take a sit in the board of directors and deploy their professional network of contacts.

Because of the uncertain circumstances, entrepreneurs managing early stage ventures would like to turn to their venture capitalists more frequently for advice and informal counselling than those with later ventures (Sapienza and Amason 1993). Further, both investors and investee are more likely to rely on informal channels of communication in the early stage (Daft and Lengel 1986). The trust that develops through repeated interactions stream-lines the interaction process and Sapienza and Amason (1993) found that as managers share increasing amounts of tacit knowledge, overt communication becomes less important and therefore the venture stage is negatively related to the frequency of venture capitalists – portfolio companies interactions. In terms of policy making the

higher frequency of venture capitalists- entrepreneurs interaction in earlier stages supports the view that venture capitalists are more important in the early stages of the venture (Sapienza and Amason 1993).

The extent of interaction between the venture capital fund and its portfolio companies has also been examined by Gorman and Sahlman (1989). Venture capitalists spend more than half their time with their portfolio companies, and when they play a lead investor role, they devote much more time than non-lead investors or late-stage investors do (Gorman and Sahlman 1989). The absolute amount of time devoted to companies by active investors would not support a view of venture capitalists as individuals deeply involved on a day-to-day basis in the management activities of their portfolio investments. Indeed a typical early stage investment gets a little more than two hours of direct attention per week from its lead venture capitalist. Non-lead venture capitalists contribute another three-quarters of an hour per week. Even when another VC firm leads the investing, a venture capitalist will still typically visit the company at least once per quarter. In total, monitoring and advising occupies about half of the venture capitalist's time (Gorman and Sahlman 1989). Gorman and Sahlman (1989) found that the most performed service for portfolio companies it to help raise additional funds, with strategic analysis and management recruiting also mentioned as important roles.

Hochberg et al. (2007), examined the performance consequences of networking in the context of relationships established when venture capitalists syndicate portfolio company investments. They found that strong relationships with other VCs likely improve the chances of securing follow-on VC funding for portfolio companies, and may indirectly provide access to other VCs' relationships with service providers such as headhunters and prestigious investment banks (Hochberg et al. 2007). Controlling for other known determinants of VC fund performance such as fund size as well as the competitive funding environment and the investment opportunities available to the VC, they found that venture capitalists that are better-networked at the time a fund is raised subsequently enjoy significantly better fund performance, as measured by the rate of successful portfolio exits over the next 10 years (Hochberg et al. 2007).

The literature review shows that there is a strong body of research concerned with VC fund-business interactions, analysing and measuring the extent of interaction and also the reasons that may influence such extent (Gorman and Sahlman 1989; Sahlman 1990). However, the analysis of VC funds with other bodies outside the strictly VC-business framework but still within the finance community is very scarce. This thesis extent the literature by investigating, mapping and measuring

the extent of interaction between venture capital funds with other members of the finance community such as business angel networks, banks, companies outside the portfolio. There is also little analysis on how the VC community interacts with the outside world. Therefore, this thesis aims to provide the first detailed empirical investigation of the relationship between VC and other players of the innovation system such as universities incubators, research institutes, and regional authorities.

Universities are seen as important means of knowledge creation and diffusion. A large exploitation of knowledge transfer and commercialisation activities began after 1997 (UNICO 2005). University spin-out companies attract a significant proportion of the UK's venture capital. According to the Library House (2007) university spin-out companies raised almost 12 percent of all venture capital investment in the UK.

Business incubators - a facility that provides affordable space, shared office services, and business development assistance in an environment conducive to new venture creation, survival, and early-stage growth (Allen and McCluskey 1990) – are also important players of the regional innovation system. Recently, the concept of business incubation has been expanded in order to accommodate the needs of the internet economy:

''dubbed "business accelerators" "campuses," "econets," and "Internet keiretsus," these organizations have become the hot new way to nurture and grow start-ups in the Internet economy. They offer fledgling companies a number of benefits - office space, funding, and basic services such as recruiting, accounting, and legal - usually in exchange for equity stakes'' (Morten et al. 2000, p. 75).

The nature and range of such institutions and their interrelationships might be expected to vary across regions due to regional government and governance structures, differential investment in regional innovation systems and policies and the regions dependency on public or private institutions (see Cooke et al. 2003).

There has been very little research to date on mapping and understanding the relationships between the different regional bodies and how they may affect the overall innovation system (with the only exception of universities where considerable amount of work has been undertaken on the role of VC in stimulating university spin outs). The ambition of publicly backed funds to meet "soft" objectives has led them to expand their network of contacts inside and outside the venture capital community in order to include bodies that would not have been included had it not been for these objectives.

Previous studies have shed light on the relationship between venture capitalists and their portfolio companies (Gorman and Sahlman 1989) between venture capital funds with other venture capital funds (Hochberg et al. 2007), networks of service providers such as head hunters, patent lawyers, investment bankers (Gorman and Sahlman 1989, Sahlman 1990) and universities (Wright et al. 2006). The common parameter in these studies has been an investigation on how these relationships may affect the VC backed company's performance and consequently the financial performance of the fund. However, these studies have two important limitations that impede their relevance to the research questions of this thesis. First, they do not distinguish between private and public funds and therefore their findings may not necessary apply to publicly backed funds since such funds have often additional or different objectives to private funds. Second, existing studies are mainly concerned with the likely impact that interactions between VC funds and other bodies may have on the fund's financial performance and therefore do not investigate the likely impact of these interactions in regional innovation. As a result, very little is currently known as to the role of the publicly VC backed funds in spurring innovation at the regional level.

2.6 Conclusion

There has been a growing interest amongst scholars in the relationships and interactions that constitute regional innovation systems. The policy implications of this new approach have been dramatic, since they have involved a fundamentally different way of government intervention than the traditional neo-classical emphasis on knowledge creation. Instead, public intervention is now encouraged to focus on facilitating knowledge diffusion, which requires a policy of creating conditions in which the dynamic process of technological development can prosper (Corvers 2000).

The aim of this chapter has been to provide a comprehensive overview of the literature on issues that are closely related to the study of venture capital and its role in innovation, with a particular emphasis on public policy and its regional dimension. It began by illustrating the change in the meaning of the regional boundaries and how it has moved away from the strictly territorial and administrative definitions. It then reviewed the central theories to regional development and how they have changed in time, emphasising the theoretical link between innovation and economic development which has significantly strengthened by a number of scholars that argued for the importance of intangible assets. It continued by illustrating the importance of venture capital as a source of finance and the growing literature on the role of venture capital in spurring innovation and growth, and highlighted the importance of space in the VC industry. It concluded by reviewing the theories on information asymmetries in the venture capital industry.

The importance of intangible assets has become synonymous with innovation capacity in space. Investments in R&D, technological innovation and personal development through learning are seen as essential factors of increasing the innovation capacity of the region. In that sense, venture capital has been identified as a key element of innovation finance. Despite the importance of this type of finance and its relationship to innovation, the literature review shows that very little research has been undertaken on the relationship between venture capital and regional innovation. Indeed, research on the role of venture capital in the regional innovation system has been very limited to date.

In pursuing the examination of the relationship between venture capital and regional innovation, the thesis mainly builds on the following theoretical premises: the work of Mason and Harrison (2001, 2002) who found large disparities amongst the UK regions with London and South East dominating the industry, on pioneering work of Gompers and Lerner (2001) and Kortum and Lerner (2000) who found that venture capital spurs innovation, the work of Brander et al. (2010) on the relationship between government backed venture capital and patenting and on the work of various scholars that examined interactions within the VC community (Sorenson and Stuart 2001; Rosenberg 2002; Smith 2005; Pinch and Sunley 2009). However, in the present study an attempt has been made to go beyond the work of those researchers in three ways: first, in their examination of regional differences, Mason and Harrison (2001, 2002a) focused only on the supply of VC in this regions and the potential impact of the publicly backed VC in a regional context; in contrast, although this thesis also focuses on the supply side, it investigates the combination of VC in this regions by providing a detailed analysis of the extent of VC public dependency of each UK region. It also elaborates on previous analysis undertaken by those researchers on the potential implications of t public sector dominance in several UK regional innovation systems. Second, this study extend the work of Kortum and Lerner (2000) who measured the impact of VC in innovation using patents as a proxy variable for business innovation and Brander et al. (2010) who examined the relationship between patenting and government backed VC funds using a global sample. This thesis extends this analysis by investigating the relationship between different sources of VC and their impact on innovation using again patents as a proxy variable for business innovation but focusing on the UK regional level and using a much larger study sample than Brander et al. (2010). Third, in looking at the interactions between VC with the external world, the literature mainly focuses on the relationship between venture capitalists and investee companies. Sapienza and Amason (1993), Smith (2005) and others have examined potential factors that may impact on the former relationship and have collected data from matched pairs between venture capitalists and investee. In contrast, this thesis investigates the extent of interaction between venture capitalists and other internal and external bodies such as

business angel networks, universities, and business incubators. Although it does not analyse empirical factors that may be responsible for such relationship and it collects data from VC fund managers only, it provides a new insight into the differences in the extent of interactions between different types of venture capitalists and the outside world.

3 CHAPTER 3: POLICY FRAMEWORK FOR VENTURE CAPITAL IN THE UK

3.1 Introduction

Governments around the world have taken measures to support venture capital by creating a favorable environment with regulatory frameworks which effectively stimulate private investments and channel high risk resources to innovative SMEs.

As Lerner et al. (2005, p.3) remarked, *"it is instructive to observe that all venture capital markets of which we are aware were initiated with some form of government support. These markets do not appear to emerge without some form of assistance."*

As previously mentioned, the spatial concentration of venture capital funds and investments in London and the South East, alongside the considerably lower firm start ups in the non core regions, prompted the UK government to inject a regional dimension to venture capital policy in 2001 by introducing Regional Venture Capital Funds (RVCFs) for each of the English regions managed by local fund managers who are assumed to have local knowledge about the area. By increasing the supply of equity in all the English regions this policy response reflected the government's perception that the low rate of business R&D expenditure, start up and successful development in the non core regions is partly attributable to a 'funding gap' in the availability of equity. Consequently the availability of venture capital now occupies a prominent position in the UK policy agenda. This chapter outlines the role of public money in the UK early stage finance market, and how the 2008 financial crisis has exacerbated the market failures that public intervention sets out to address.

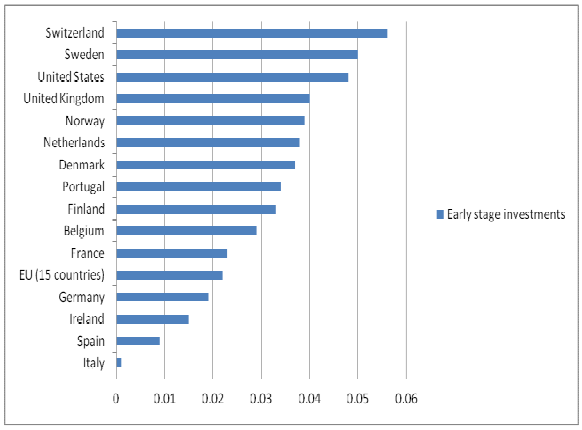
More particularly, this chapter is concerned with four issues. First it provides a historic overview of the UK venture capital industry and illustrates where it sits within the UK financial ecosystem. Then it continues by highlighting regional imbalances and shortages in terms of VC activity. It continues by analysing policy initiatives undertaken as a response to these imbalances, and the persisting equity gap. It concludes with an analysis of the impact of the current crisis in the VC industry.

This review is important for this research as it emphasises the volatility of the industry and the important role of public policy in filling the 'equity gap' and encouraging venture capital activity in the UK regions. In addition, it scopes certain spatial differences in the VC industry in the UK which is an important aspect of the research.

3.2 Historical overview of venture capital in the UK

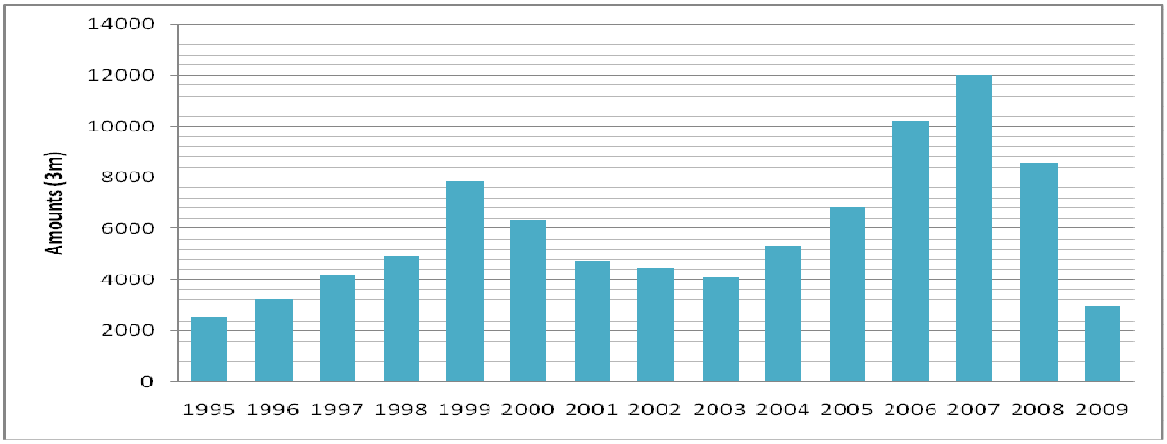
The UK private equity market evolved from a small and fragmented base in the 1980s to a respectable size in late 1990s. Currently, the UK boasts the largest private equity market in Europe, accounting for one in every three investments and 38 percent of all invested amounts (EVCA 2009). This expansion in investment activity has been driven by expansion and management buy-outs and buy-ins rather than early stage investments. Looking solely at the venture capital industry, in 2009, the UK boasts the second largest venture capital market (after France), accounting for 21 per cent of all invested amounts (NESTA 2010). The UK performs worse when only early-stage investments are considered, ranking behind Switzerland, Sweden and the U.S. in terms of early stage investments as a proportion of GDP (Figure 2).

Figure 2: Early stage VC investments as a proportion of GDP per country, 2008



Source: Eurostat

Figure 3: UK Private Equity investments by BVCA members, 1995-2009



Source: BVCA Investment Activity Report, various years

UK private equity investments (venture capital, expansion, replacement capital, management buyout and management buy-in), grew enormously during the 1990s. By 1999, some £8 billion was invested in promising companies (Figure 3). Overall 1997-2000 saw a rapid increase in capital volumes throughout the capital markets and in the market value of listed companies. Internet-related companies, bolstered by massive market capitalisation, buoyed common stock indices to unprecedented highs: many companies participated in public stock offerings without having concise business plans, workable operating models or even a hint of profitability (Cegielski et al. 2003). These extremes in investors' behaviour "defied common sense", and many scholars and industry practitioners have tried to identify what went wrong. Dave and Rein (2004) examined the investors' behavioural characteristics, arguing that there was a perception that the e-business models did not need to follow traditional, tried and true, financial criteria for success. Min et al. (2008) highlighted attributes that led to the dotcom crash including: excessive advertising and promotional costs; failure to identify a niche area; underestimation of upfront infrastructure costs; customer acquisition costs; and order fulfilment costs. The collapse of the market in 2000 is probably due to a combination of all these factors.

Whatever the reason, the result was that private equity severely contracted during the crisis. Statistics on investment activity collected by the British Venture Capital Association (BVCA) (Figure 3) show a collapse in private equity investment in the immediate aftermath (2001-2003). As a response to a growing "funding gap" that followed, consecutive UK governments implemented initiatives to improve access to finance for small high growth firms. Several high-profile interventions, designed to facilitate early-stage investment, have focused on the 'supply-side' of the investment market. These included the High Technology Fund in 2000, University Challenge Funds 1999-2001, Regional Venture Capital Funds and Early Growth Funds between 2002 and 2004, and more recently Enterprise Capital Funds (2005). Tax incentives that were introduced in the mid 1990s, including the Enterprise Investment Scheme (1994) and the Venture Capital Trust (1995), were reinforced and supplemented by the Corporate Venture Scheme (2000). These schemes represented an attempt by government to address the supply-side problem by using fiscal incentives to draw more capital into the VC market by providing incentives to individuals and corporations to invest in high growth companies. A detailed description of all venture capital publicly backed initiatives is available in Appendix I.

During 2003-2007, the market saw strong signs of recovery. According to BVCA (Figure 3), the value of private equity investments trebled between 2003 and 2007 from £4bn to nearly £12 billion. Detailed examination of these aggregate statistics indicates that this upward trend in investment

activity has been driven by a huge increase in funding for management buy-outs and buy-ins (MBOs and MBIs) rather than VC investments. The most important factors contributing to this recovery of the private equity market have been liquidity in the credit market, the tremendous growth of Private Equity funds and the rise of hedge funds (Acharya et al. 2007). This liquidity boom was propelled by increased investment from petrodollars, huge government surpluses, particularly from Asia, as well as pension, foundation and private wealth (Altman 2007). This explosion of liquidity which fuelled an unprecedented supply of finance to the industry ended with the banking crisis in 2008.

The current financial crisis and the accompanying downturn are severely affecting the VC industry. First, falling stock markets and poorer trading environments make it harder for funds to sell or float their existing investments. Second, several limited partners suffering from liquidity problems are unable to fund further investments. Third, several institutional investors have reduced their exposure to the VC market while others are leaving the early stage market (NESTA 2009).

Table 2: UK early stage investments 2000-8

(a) Amount invested (£m)

Finance stage	2008	2007	2006	2005	2004	2003	2002	2001	2000
Start-up	172	190	531	160	96	73	99	163	175
Other early stage	187	244	415	222	188	190	196	227	528
Total early stage	359	434	946	382	284	263	295	390	703
Early stage as a % of total investment	4.1	3.6	9.3	5.6	4.2	6.5	6.6	8.2	11.0

Source: BVCA Report on Investment Activity (various years)

(b) Number of companies

Finance stage	2008	2007	2006	2005	2004	2003	2002	2001	2000
Start-up	170	207	245	208	190	185	165	190	153
Other early stage	285	295	255	285	264	242	233	218	256
Total early stage	455	502	500	493	454	427	398	408	409
Early stage as a % of total investment	36	38	38	38	35	34	33	31	35

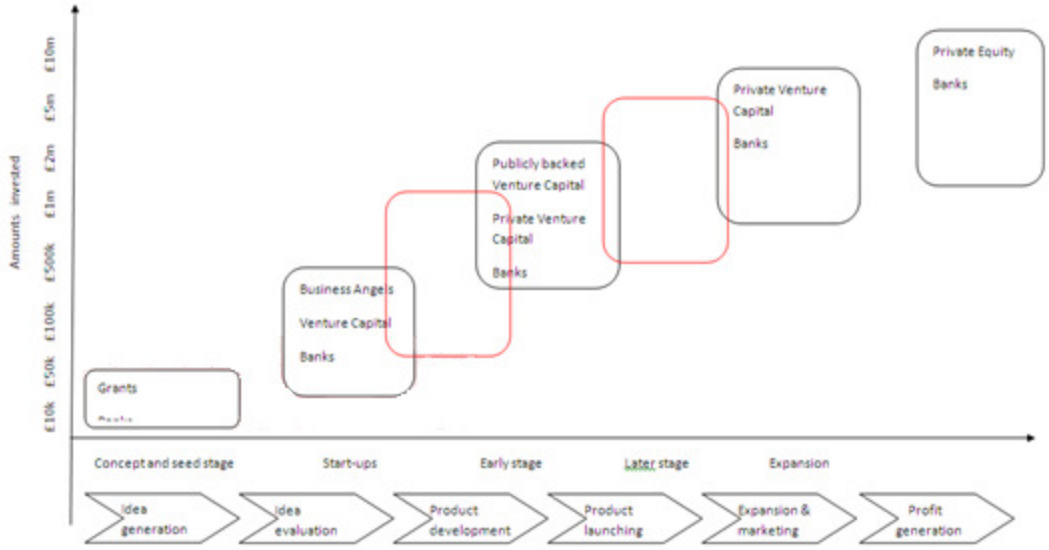
Source: BVCA Report on Investment Activity (various years)

As discussed in the previous chapter, venture capitalists make their most important contributions in the earliest stages of new ventures (Bygrave and Timmons 1992). Early stage investments have fallen since 2000 in terms of amount invested, apart from the anomalous year of 2006, and their share of total investment activity has been less than 5 percent in recent years (apart from 2006). Numbers of early stage investments, in contrast, have modestly increased since 2000 (Table 2b). Taken in conjunction with trends in the amount invested, this indicates that there has been a decline in the average size of early stage investments. It is also worthy of note that the number of early stage investments remained static in 2008 whereas the amount invested fell by 17 percent (Table 2a).

3.3 The place and size of venture capital in the UK's financial architecture

The provision of sufficient finance to high growth companies requires the establishment of effective financial systems that support innovation and growth.

Figure 4: Business Finance Architecture



Source: NESTA 2009

New high-growth firms need different kinds of support depending on their stage of development. They thrive if there is a smooth progression from one type of funding to the next (CBR 2009). Figure 4 illustrates the journey of company growth from idea generation to profitability. Different sources of capital are relevant at different stages of the firm's development. The former Department for Innovation, Universities and Skills described this as an *"escalator of financial support for innovative businesses at different stages of their growth"* (DIUS 2008, p. 38).

The blank boxes in Figure 4 represent those steps where finance is hardest to obtain. They need particular attention from policymakers. Most investors and entrepreneurs observe that an "equity gap" exists for investments from £250.000 to £2 million; others have identified a second equity gap which stretches up to £5 million (especially for the medical and pharmaceutical sector) (NESTA 2009).

3.3.1 Informal venture capital

Informal venture capital investments which are mainly made by Business Angels play an important role in first stages of company's growth. Venture capital, because it is typically organized around limited and general partnerships, has formal reporting requirements such that the activity, strategies, and financial returns are at least well publicized, and possibly well understood. Angel capital on the other hand, is typically invested by individuals investing their own money directly into opportunities that they find attractive. They have no partners to formally report to, make smaller investments than formal VC's, and as a result we know relatively little about the activity, strategies, and financial returns to business angel investing (Wiltbank 2009).

Over the past decade Business Angels have become an increasingly important source of equity finance for new and nascent businesses (HM Treasury 2008) as venture capital funds are not able to accommodate a large number of small deals with heavy due diligence requirements (EC 2002). The UK Government recognises the vital role that Business Angels play in the funding of early stage businesses and in helping to fill a difficult void in supply, where businesses are graduating from debt to equity finance but are also a critical source of advice, guidance and support for entrepreneurs (HM Treasury 2008).

Despite their increasing importance, in depth information on the outcomes of Business Angels investing, returns and exits has been lacking to date in the UK. Mason and Harrison (2002b) conducted the first attempt to identify the returns and characteristics of the UK Business Angel Investors, pointing out the lack of evidence on the outcomes of investments by Business Angels. In that research they suggest that this represents a significant gap in our knowledge and understanding of an important segment of the venture capital market. NESTA (see Wiltbank 2009) conducted a study on the Business Angels characteristics, performance and activities. The study surveyed 158 UK based angel investors that made over 1000 investments and found that on average they made 22 percent returns (IRR). Most angel investing is done within 250 kilometres of the investor's home, though 25 per cent of investor were willing to make investments abroad. Angel investors are typically male (93 per cent) and they invest on average £42,000 each. The typical age of the business angel was 53 with significant professional experience in large companies (13 years). Most have

founded several new ventures themselves, virtually all had university degrees and more than half had advanced degrees.

Business Angel investors generally represent the first significant outside capital invested in start-up companies. After an entrepreneur or team of entrepreneurs identify a business opportunity and invest their own resources, they often turn to business angel investors to provide seed or early capital. At this point in the development of new ventures the risk of failure is significant as frequently parts of the business model, customer relationships, pricing strategy, talent, and other key factors are still exposed to high ambiguity.

Although there is no comprehensive survey of business angel activity available in the UK, it is estimated that in 2000 there were between 4,000 and 6,000 Business Angels, investing up to £1bn annually (Lord Sainsbury 2007). A latest estimate puts this figure at £469m per year (BIS 2011). In the US as a comparison, there are currently approximately 258,200 active business angel individuals which invested over $26 billion in 2007 in 57,120 entrepreneurial ventures according to the Centre for Venture Research at the University of New Hampshire Centre for Venture Research. It is therefore clear that there is considerable scope for further investigation and development of this area of investing.

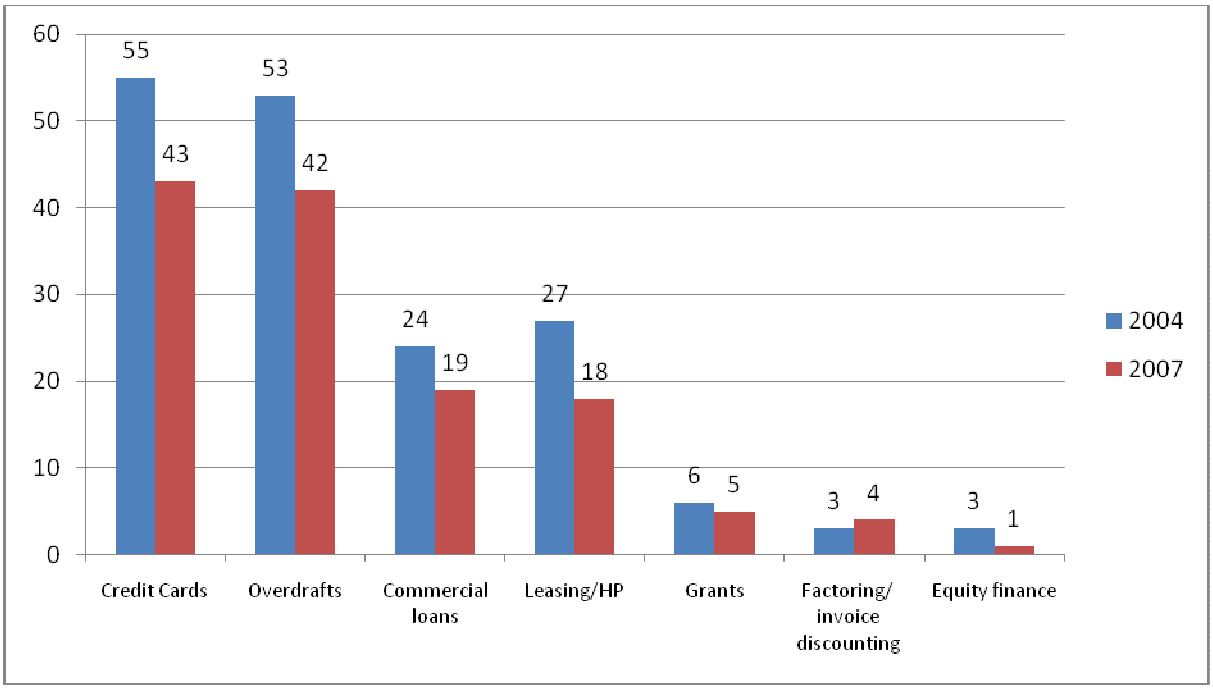
3.3.2 External sources of firm finance

Bank finance is by far the main source of finance for UK based businesses. As Figure 5 shows over 50 per cent of businesses use credit cards or overdrafts to finance their ventures while approximately one quarter of them use bank loans.

At first glance, finance for growth businesses appears to present only a limited problem. A recent European Commission report (EC 2009) showed that only 19 per cent of UK small and medium-sized enterprises saw limited access to finance as a constraint. Although this figure was higher than that in other European countries (it was just 7 per cent and 9 per cent respectively in Finland and Denmark), it at least implied that the vast majority of the UK firms are able to secure external finance.

However, this figure conceals a difference between different types of firm. As Figure 5 shows, the majority of firms accessing finance relied on small-scale debt finance: credit cards, overdrafts and commercial loans.

Figure 5: External sources of finance - percentage of business using various financial products



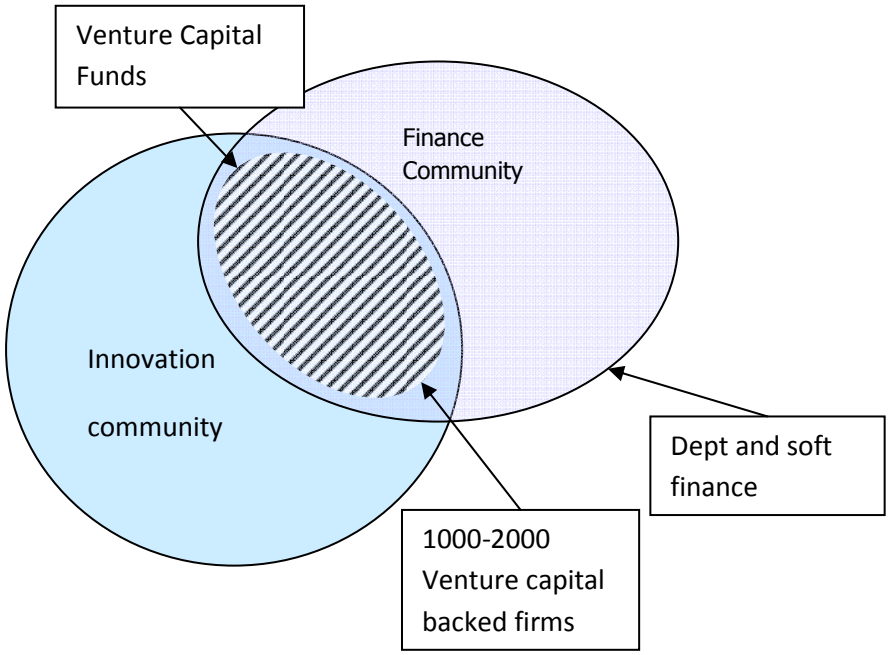
Source: CBR 2008

The high-growth firms described earlier often do not fit into this category, especially in their early years. These companies require significant capital up front. And this is very hard to obtain from conventional sources of debt finance. They tend to have intangible assets, and show a significant delay before generating revenue making than a high risk investment. These firms are some of the most attractive growth prospects, and include start-ups in the information technology, life sciences and advanced engineering sectors. They rely on early-stage equity finance: venture capital and angel investment.

3.4 Venture capital finance

Different estimates put the number of businesses in the UK that are reliant on venture capital are approximately one to two thousand (Thomson One, Reuters).

Figure 6: Regional Innovation System and Regional Finance System



Source: Author's research and Thomson Reuters

The financial system contains three main sources of finance as we saw earlier (debt, soft and equity) but this thesis concentrates only on the part of the financial systems which is more connected to innovation i.e. venture capital. In Figure 6, the lighter shaded part of the finance community cycle represents debt and soft finance. The darker shaded part of the cycle which partly overlaps with the innovation system cycle represents the venture capital community and includes the 1000 to2000 innovative companies that receive VC funding.

Venture capitalists' location in the centre of a system of tacit knowledge exchange provides them with a great deal of hard to acquire know-how and know-who but they are not the only actors who possess these skills and connections. Others are well informed about technological breakthroughs and key players in industries or are familiar with growing companies. Entrepreneurs themselves can make connections with suppliers, customers and strategic partners, although it may take considerably more time to do so. What sets venture capitalists apart is their ability to speed up this process to the extent that companies gain a significant competitive advantage (Zook 2004).

3.5 The role of government in early stage investment

The UK government has increasingly recognised the importance of early-stage equity investment for economic growth and innovative activity and the existence of an equity gap – the inability of small

firms to access the finance they need to grow – has been a long-term challenge for British governments. Successive administrations have acknowledged the importance of the VC industry and implemented various initiatives in support of early stage venture capital investment, including seed and start-up funding. There are three main categories of UK government programs which intend to mobilise venture capital in support of SMEs: 1) direct supply of capital to small firms, 2) direct supply of capital to investment funds which will then invest in small firms, 3) financial incentives for investing in SMEs (e.g. tax credits) particularly focused on the informal VC investors i.e. Business Angels. But six decades after the first government intervention in support of finance to SMEs, there is still no consensus as to what constitutes an effective model of government intervention.

Around the time of the Second World War, government thinking focused on plans to institutionalise business finance, by creating new organisations to provide funding to small and medium enterprises (the Industrial and Commercial Finance Corporation, ICFC, which later evolved into 3i). Tax incentive schemes to promote investments and the availability of external finance to business were originally introduced in 1983 and were replaced in 1990s by the Enterprise Investment Scheme and Venture Capital Trusts. Towards the end of the 1990s, a number of new initiatives were introduced, targeting different sub-segments of the early stage market, namely the regional Venture Capital markets (Regional Venture Capital Funds), university spin outs (University Challenge Funds) and very small business (Enterprise Guarantee Funds).

The introduction of Enterprise Capital Funds (ECFs) in the new century saw the government's focus shift to incentivising private investors to co-invest with publicly backed venture funds, in the case of ECF by providing 2:1 matching of private capital.

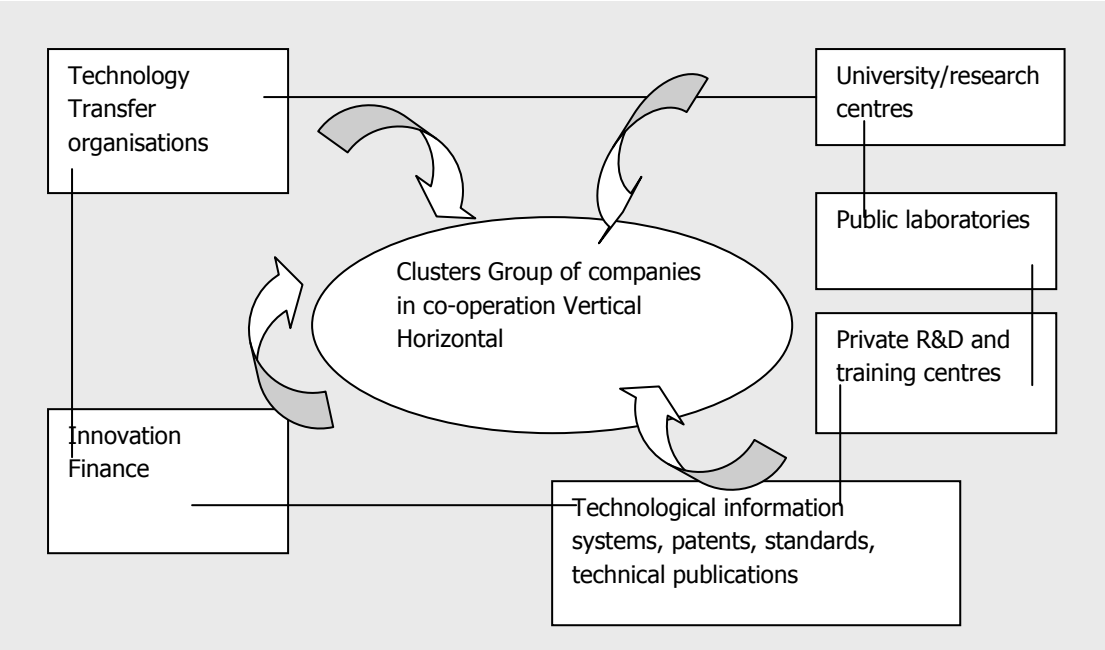
This, in turn, has prompted a profusion of public sector schemes both in the UK and elsewhere which Murray (2007, p. 174) notes was a clear signal "*of venture capital's status as an important instrument of entrepreneurial and innovation policy*." Many of these government venture capital programmes have been regionally-based, notably the Regional Venture Capital Funds and various funds established by the Regional Development Agencies in England and the Regional Development Agencies in Wales, Scotland and Northern Ireland. This has been partly for efficiency reasons (e.g. to use local knowledge and networks, co-ordinate better with other local economic policies) and partly to address gaps in the supply of finance in specific regions (regional equity gaps) (Sunley et al. 2005).

Between 2000-2009, the government placed around £337.9m in these schemes. Other investors contributed a further £438.2m making a total of £776.1 million available to business (NAO 2009).

3.5.1 Supporting innovation through publicly backed VC initiatives

The publicly backed schemes in support of high growth business finances implemented by the UK government have significantly changed the landscape of the innovation system by placing innovation finance at the very centre of activity.

Figure 7: Traditional Approach of Regional Systems of Innovation

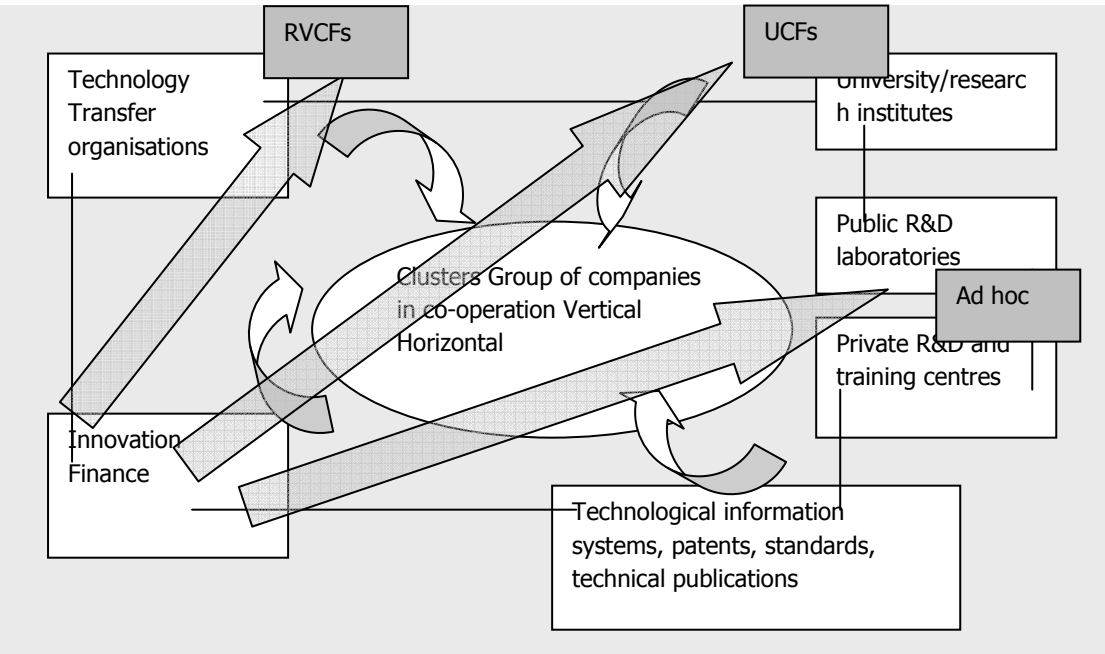


Source: Komninos 2004

In the traditional approach of the regional innovation system (Figure 7), venture capital appears to contribute directly to the development of firms and clusters and has direct links with technology transfer organisations. It appears that due to the recent developments on innovation ecosystem, innovation finance has been reinforced and it has now become integral part of many other critical component of the regional innovation system (see Figure 8).

In fact, Cooke et al. (2002) argue that a number of elements of what they call private-led innovation systems are evident in some UK regions (e.g. Viridian in N. Ireland), such as university incubators, spin-out firms, venture capital, exacting technology customers, supply chains, cluster-building programmes, science park facilities and science entrepreneurship support.

Figure 8: Financial Activity within the Regional Innovation System



Source: Komninos 2004, author's research

A current look at the main components of the regional innovation system reveals that most of them have been actively involved with some type of venture capital activity in the last decade (Figure 8). For example, there has been a culture change in the UK's universities over the past decade. The University Challenge Fund Scheme was announced by the Chancellor of the Exchequer, in March 1998 as collaboration between the Government, the Welcome Trust and the Gatsby Charitable Foundation to assist universities in turning research projects into viable businesses. The competition was launched in June 1998 and all universities were invited to apply. Collaborative bids involving other Higher Education Institutions and Public Sector Research Establishments were also invited.

The first University Challenge Competition created 15 seed funds allowing 37 institutions (31 universities and 6 institutes) access to investment capital. The total value of the funds created (including the 25 percent matching funds required from the participants) was in excess of £60 million. The seed funds established from the first competition have been between £1m and £5m with the ability to make single investments to a maximum of £250,000 per investment. The progress of the funds will be monitored for 10 years by collecting annual reports to a common format. The second annual report (2000-2001), showed that £11.9 million of investment has already been committed. A total of 143 projects have been supported by the 15 seed funds with an average investment of £83,000. The University is the trustee for the funds, which are held in a dedicated account (Druilhe and Garnsey 2004).

Knowledge transfer and commercialisation activities have steadily increased since the early 1980s, however the large exploitation of such activities began only after 1997 (UNICO 2005). In 2007, there were over 590 university spin-out companies in the UK which attract approximately 12 percent of all the UK's substantial venture capital finance, and to date these companies have raised a total of over £2bn in external investment and many have floated at substantial valuations (Library House 2007).

3.5.2 Evaluations of government schemes

There have been several evaluations of the government schemes so far. The first one conducted by NESTA (2009) performed a qualitative evaluation of the public funds and highlighted several operational issues concerned with their effectiveness. NESTA argues that many publicly backed funds (e.g. Regional Venture Capital Funds and University Challenge Funds) face difficulties owing to the fact that they have multiple objectives: for example to deliver both a commercial and a social return, or to encourage regional development (NESTA 2009).Indeed, the more objectives a fund has (either explicitly or tacitly), the less likely it is to satisfy any of them. Explicit non-financial objectives also make it harder to recruit an appropriate team: at present, investment professionals with the skills to undertake economic development work are rarely those with the best track records of backing and developing profitable companies (NESTA 2008c).

According to NESTA (2009), public funds also frequently suffer from problems of size. Firstly, they are in some cases too small to operate effectively, either not being able to do make enough investment to justify their operating costs, or not spending sufficient money on staff and operations to make good investments. Secondly, small funds are particularly likely to make small investments, which can often be self-defeating, as investees spend too much time looking for their next funding round and not enough time building their business.

A number of publicly backed funds are geographically focused, with a requirement to concentrate on certain English regions or UK nations. NESTA (2009) argues that although venture capital certainly has a role to play in stimulating regional economies, limiting funds to regions has significant risks. Firstly, it is often associated with being very small and having mixed investment objectives, as outlined above. Secondly, it constrains funds' ability to source high-quality investments: economic activity frequently crosses the borders between regions, which in the UK are relatively small in geographic terms. This means that a fund that can only invest in its local region is likely to turn down many potentially attractive but non-local investments it encounters, reducing its chances of striking good deals.

Another evaluation conducted by NESTA and BVCA (2009) focused on the effectiveness of these funds on business performance. The researchers conducted an econometric analysis of the impact of investment from six UK government backed venture capital schemes was conducted on a detailed data-set of 782 funded young firms over the period 1995-2008. The impact of these schemes on firm performance, was compared to a matched control sample with companies that have never received VC investment. The study found that the size of this impact remains small to date albeit longer term trends appeared encouraging (from limited information). The analysis finds repeated positive and encouraging evidence of firms that have received funding engaging in venture capital style 'equity investment' behaviour. While producing an initial negative impact on firm performance, firm growth rebounds strongly after a number of years. The analysis suggests it takes approximately 4-5 years to turn performance around.

The report recommends that government backed, hybrid venture capital funds should be substantially larger than they have been in the past in order to allow them to provide follow-on funding, diversify their investments and spread their high fixed costs. Government policy should also recognise a tension between regional policy and innovation policy. Outside the major metropolis of Greater London and the South-East, funds that are limited to certain geographical regions are unlikely to have a sufficiently large enough pool of high-potential firms to be commercially viable. Large, specialised and successful venture capital funds are increasingly likely to operate at a continental and/or transatlantic scale in the European Union.

The National Audit Office (2009) conducted an evaluation of the schemes to assess the financial performance of these funds. The evaluation found that the government has set multiple aims for each fund but these have not been translated into clear measurable objectives, or been appropriately prioritised. With the exception of the Enterprise Capital Funds no clear financial objective was set for the impact of the funds to the taxpayer, such as whether they were expected to break-even and over what timescale, and the Department did not specify objectives for wider economic benefits. Therefore the evaluation could not conclude whether the funds met their objectives or not, since these objectives were never clearly identified.

The authors of the report surveyed business groups, businesses and fund managers that were involved in the schemes. Eighty four per cent of businesses surveyed by NAO for three of the funds reported that the initial funding had made it easier for them to obtain additional finance from other sources. Without support, most of those who would have proceeded anyway would have delayed their plans or reduced the scale of their activity. Publicly supported venture capital was not the only source of funding available to these start-up companies. Thirty two per cent of businesses reported

they would have been unable to obtain any finance without support from the funds. Around 23 per cent reported that they would not have gone ahead with their planned activity in the absence of finance from the Department's funds.

The financial performance of the funds has also been very poor (although not untypical when compared with private VC returns over the same period). The report also argued that the performance of the RVCFs was impeded by their design and that due to geographical restrictions the pool of viable business propositions targeted by the funds was restricted. In some cases restrictions were on the basis of investment criteria, for example their regional focus and the total allowable investment limit for a business was £500,000, which restricted the size of initial and follow-on investments.

CI Research (2007) conducted an interim evaluation of Regional Venture Capital funds (RVCFs) and Early Growth Funds on behalf of the government. Evidence from business and stakeholder surveys has revealed that both the RVCF and EGF programmes have provided finance to companies who would have been unlikely to have received equity finance from the private sector. More particularly the evaluation found that recipient businesses reported a range of benefits, from the introduction of new products and services and entry into export markets, through to the benefits received from the advice and guidance of Fund Managers. The majority of businesses have already experienced growth in employment and turnover, and many reported that much of this was a direct result of the investment of public funds. The general view amongst stakeholders (such as fund managers) was that the funds operate within the equity gap, albeit at the lower end. The funds have leveraged a substantial amount of funding into the equity gap, with very few suggesting that RVCFs and EGFs had displaced private sector funds. The predominant view amongst stakeholders was that most recipient businesses would not have secured the finance through other routes. Investment rules, in particular the upper limit on investment deals, are felt to have hindered fund performance. The upper limit has been set higher for successor programmes (e.g. Enterprise Capital Funds) but there was some concern that this would lead to a lack of supply at the lower end of the equity gap. Stakeholders report the funds have had wider benefits, including the establishment and growth of investor networks. However, a common belief was that neither scheme would deliver a lasting impact on the equity gap, meaning there was a continued role for public funds.

3.6 The impact of the global financial crisis on UK growth finance

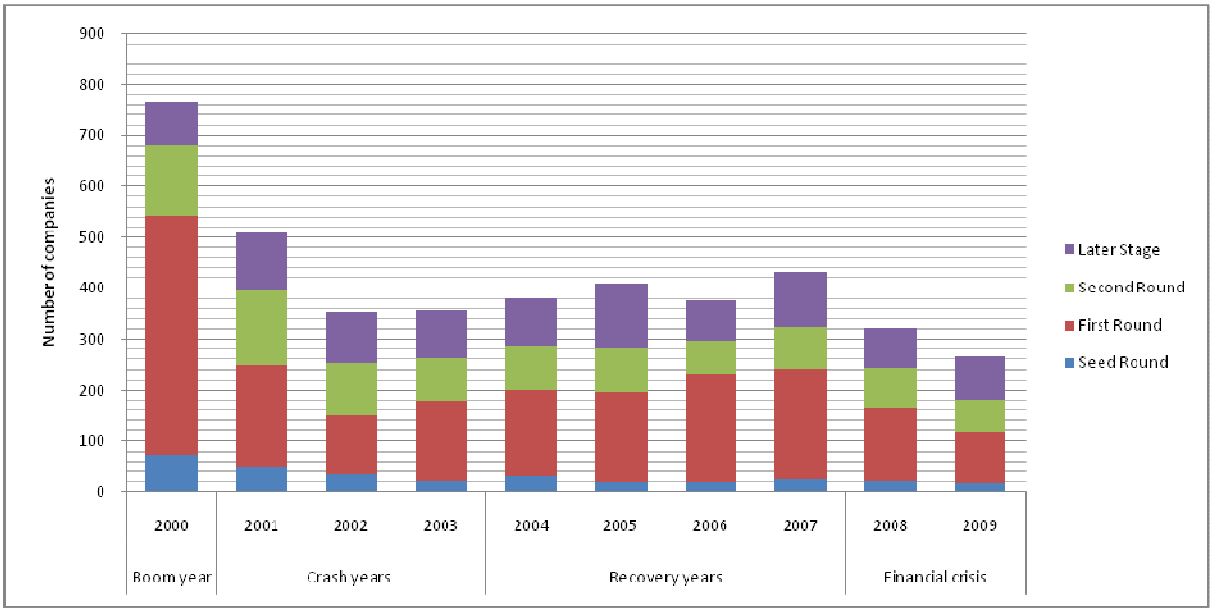
The 2008 financial crisis has made government action even more relevant to the financing of early-stage businesses. As we shall see below, it has made private capital for venture finance a scarce and dwindling phenomenon. Many small businesses face financial challenges in the recession, as banks (the main source of credit for most smaller firms) become more risk averse. But the effect on high-growth firms and the equity capital on which they depend has been even more damaging. NESTA's research (2009) has shown that existing venture funds have very little money remaining to invest, and that the rate at which new venture funds are raised has slowed dramatically. All of this raises severe challenges for the cohort of 1,000 high-potential firms, most of which will require new finance in the next 12-18 months.

The effect of the financial crisis and the accompanying downturn is the most obvious cause. Falling stock markets and poorer trading environments make it harder for funds to sell or float their existing investments, which then require further investment to keep them running, severely limiting the amount available for new investments. In addition, some funds' limited partners (financial investors) are suffering in the current liquidity crisis; there is anecdotal evidence that this too is affecting their ability to fund further investments (NESTA 2009). Finally, some observers have also noticed a trend for institutional investors (who provide the money for some venture capital funds) to reduce the amount of money going into private equity of all kinds, which makes it harder to raise venture capital funds (even though the bulk of the asset class is dominated by leveraged buy-outs, a very different type of investment).

The effect of the credit crunch on other sources of venture funding, such as angel investors, has not been studied in depth, but it seems likely that the poor performance of most asset classes in recent years will leave these rich investors with less money to invest in high-growth firms.

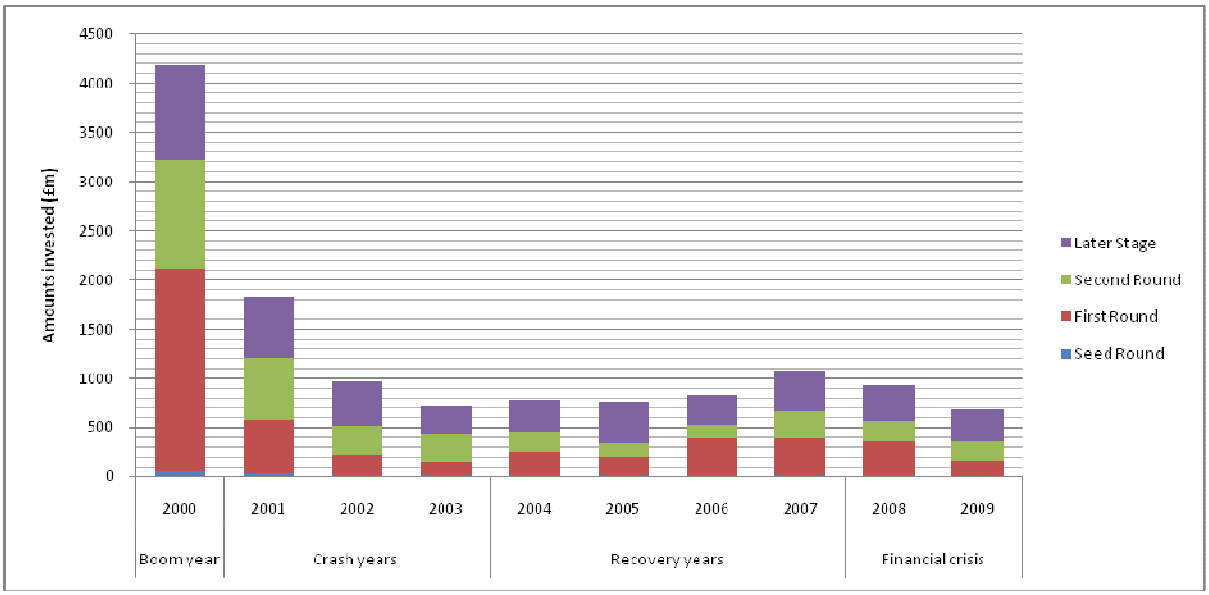
Figure 9 and Figure 10 show the number of recipient companies and total amount invested respectively, by stage and year for the decade from 2000-2009. Reported figures include only disclosed amounts. The decade is split into four chronological periods: 2000-boom year; 2001-2003 – crash years; 2004-2007 – recovery years; and finally 2008-2009 – financial crisis.

Figure 9: Venture Capital Investments, number of companies by stage, 2000-2009



Source: VentureSource Dow Jones

Figure 10: Venture Capital Investments, amount invested by stage (£m), 2000-2009



Source: VentureSource Dow Jones

In 2009, venture capital investments saw a double digit decrease. The number of companies receiving Venture Capital decreased by 17 percent compared with 2008, from 322 to 266 (Figure 9). In 2009, £677m was invested by VC funds in UK companies - a drop of 27 percent compared with the year before, when £930m was invested (Figure 10). This follows falls in activity in 2008.

First time financing (seed and first round) experienced a substantial drop of 53 percent in total amounts invested and 29 percent in term of the number of companies backed since 2008. The

number of companies receiving VC finance declined by 50 percent since 2007. In the two year period 2007-2009, the UK VC market contracted by about 40 percent. More particularly, the number of companies receiving VC finance decreased by 38 percent while the total amount invested fell by 37 percent. By comparison, there was a more radical decrease between 2000-2002 where the number of recipient companies fell by 54 percent while total investment was 77 percent lower by 2002.

Strikingly, in both crises, seed and first round investments (first-time financing) have been extremely volatile and suffered the most. In fact, between 2007-2009, total investment in seed and first round companies decreased by 58 percent with 52 percent fewer companies backed. A more severe drop was experienced between 2000-2002 where amounts invested dropped by 90 percent and first stage financed companies fell by 73 percent.

The number of companies receiving VC finance (Figure 9) increased slowly but steadily between 2002 and 2005, slightly falling in 2006 and picking up in 2007. With the start of the financial crisis (2008) the number of investments fell back dramatically to 2002 levels, dropping in 2009 to the lowest level of the decade. Total amounts invested in 2009 were the same as in 2003 (Figure 10), (both after crash years).

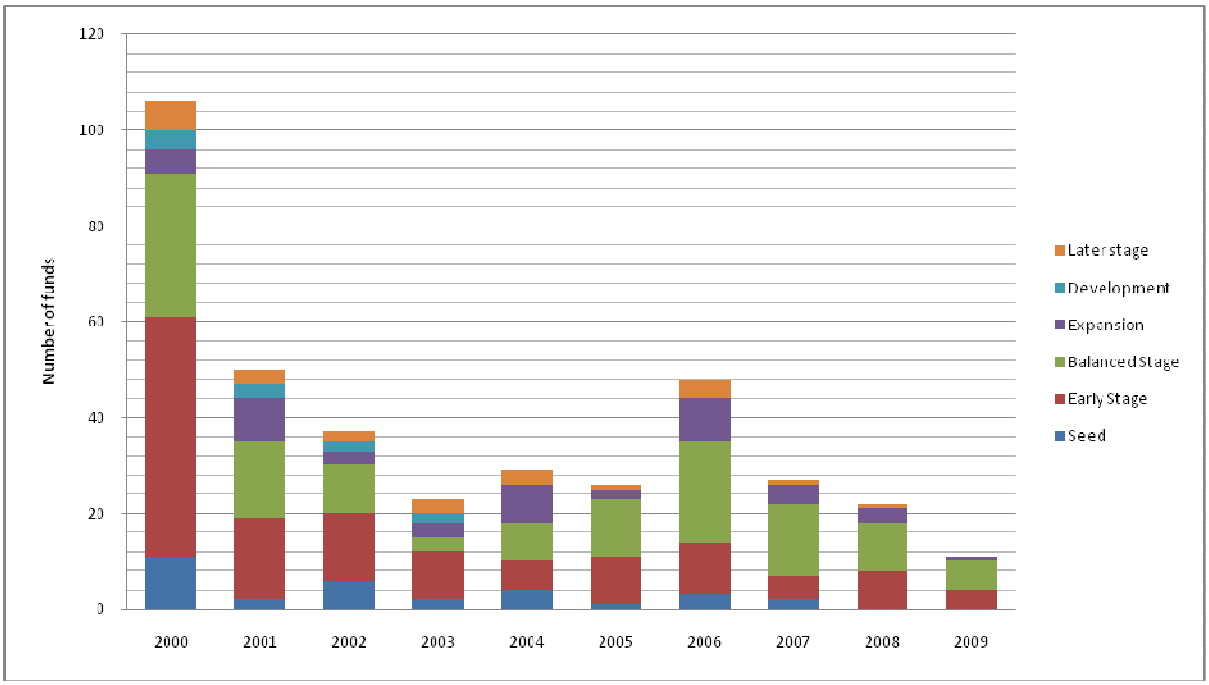
Seed and first round recipient companies have fallen from 71 percent of all companies receiving VC investment in 2000 to 42 percent in 2002, rising to 61 percent in 2006 and dropping to 44 percent in 2009. Their contribution to the market share in terms of total investment fell from 51 percent in 2000 to 22 percent in 2002, rising to 46 percent in 2006 and falling back to 24 percent in 2009.

Second stage investments have been less volatile than other investments. Their proportion of transactions has ranged from 17 percent (2006) to 41 percent (2003) and their proportion of total amounts invested has ranged from 18 perccent (2006) to 30 percent (2002). Later stage investments have consistently attracted the largest share of investment funding compared with the other investment stages apart from in 2000 and 2006 where more money went into first and second stage investments. Second and later stage investments have been modestly increasing at the expense of seed and first round investments during the last four years.

Total amounts invested and the number of companies receiving VC finance show similar distributions in both 2002 and 2009. The decline in deals and total investment reflect the diminishing fundraising trends in the UK VC market.

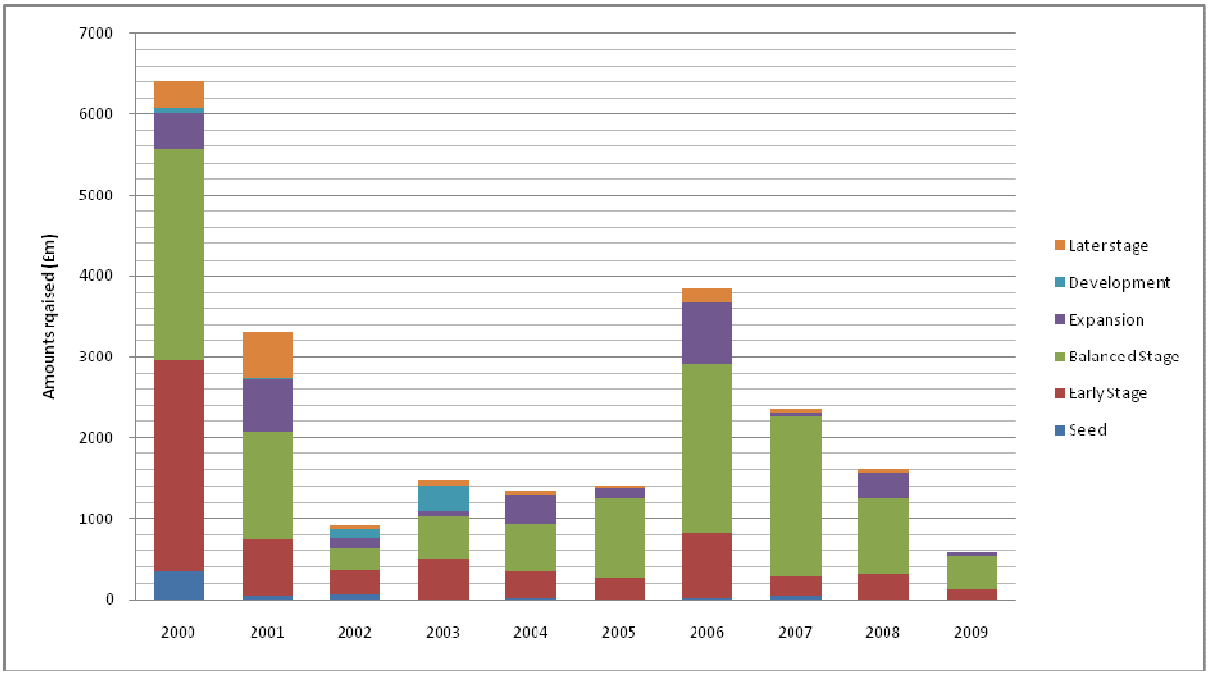
Figure 11 and Figure 12 illustrate the trends in fundraising activity during the last decade, by stage of investment.

Figure 11: Number of funds closed by stage, 2000-2009



Source: Thomson One

Figure 12: Amounts raised by stage, 2000-2009



Source: Thomson One

Long term issues may be developing as fundraising continues. According to Thomson One Reuters, there were only 11 new funds raised in 2009 compared with 22 in 2008 (a 50 percent drop) raising a

total of £573.6m compared with £1,613m in 2008 (a drop of 64 percent). Early Stage funds have also been severely affected, from eight funds in 2008 to four funds in 2009 raising £128m in 2009 compared with £329m the year before (a drop of 50 and 61 percent respectively).

The decrease in fundraising is significant and worrying as it puts at risk the VC market as a whole. The market experienced a similar decrease during the dotcom crisis. The number of funds closed fell from 106 funds worth £6,409m in 2000 to 37 funds raising £919.5m in 2002, representing a decrease of 65 percent for the number of funds and 86 percent on the amounts raised.

Early stage investments have fallen since 2000 as a proportion of total Private Equity investment and their share of total investment activity has been less than 5 per cent in recent years (NESTA 2008a). This trend is set to continue with fundraising activity for Early Stage funds further diminished.

The pattern of venture capital funding over the last decade has been characterised by a sharp decrease in the supply of funds during the dotcom crash, a steady increase during the recovery period and another sharp decrease during the current financial crisis. More particularly, the annual flow of money into VC funds increased after the earlier crisis peaking at approximately £4 billion in 2006.

3.6.1 No signs of recovery

Aggregated data suggest that there has clearly been a decline in all indicators of VC activity since 2008. In 2009, investment activity saw double digit decline, marking the lowest venture investment level of the last decade, with first time financing experiencing the steepest decline. In both the dotcom and financial crises, venture capital activity was severely hit with first time financing facing the greatest burden. Similarly, both crises resulted in a significant reduction in the number of new VC funds established in the aftermath of the crisis, when the total VC amounts raised plummeted. It is worth noting that current fundraising activity is considerably lower than in 2001.

NESTA's (2010) empirical analysis shows a significant and unprecedented increase in the time taken to exit. Companies now need approximately three extra years to realise a return compared with companies exited during the previous crisis. In addition, there is now less certainty as per the expected years needed for a company to exit. As a result, venture capitalists have slowed their appetite for investments into new companies, concentrating instead on existing portfolios that now require additional funding rounds and more time to exit. The uncertainty of the duration that a fund is expected to keep a company within its portfolio, significantly impacts in the fund's strategy which now has to reserve resources and minimise its risk appetite.

3.7 Conclusion

Rapidly growing entrepreneurial enterprises are viewed as important sources of innovation, employment and productivity growth and therefore it is natural that governments would be interested in the provision of finance for high-technology enterprises through venture capital schemes (Brander et al. 2010). The UK government has implemented various initiatives in support of the venture capital industry aiming to address the ''market failure'' that may arise in entrepreneurial finance and also aiming to generate positive spill over effects throughout the economy. However, notwithstanding the possible merits of government support for venture capital, such intervention may be subject to the usual problems often attributed to government (Brander et al. 2010). In the case of the UK, such problems include small size and poor structure of the funds, multiple objectives and geographical restrictions.

Despite their problems, the UK government schemes have helped firms to access finance. The NAO (2009) evaluation of the schemes revealed that around one third of the firms that received investments from publicly backed funds would have been unable to receive any finance without the support of the government schemes while one quarter of them, would not have gone ahead with their planned activity had it not been for the finance from the public funds. This results, illustrates that such funds help 'oil the wheels' but they are not panacea as they are not enough on their own to attract large scale private venture capital investments into the early stage market.

Finally, the current financial crisis has initiated a debate amongst scholars on the future of the venture capital industry. Some observers argue this is a permanent shift towards lower returns, raising doubts about the sustainability of the VC model (Kedrosky 2009). However, VC returns relative to the overall stock market since 2002 have not been much different than the long-term historical average, so recent returns may reflect the natural evolution of a competitive market (Kaplan and Lerner 2010).

4 CHAPTER 4: METHODOLOGY

4.1 Introduction

This chapter presents and justifies the research methodology employed by this thesis. It analyses the benefits and limitations of alternative methods of data collection and analysis used in undertaking the research. Influenced by the work of economic geographers and economists, this chapter draws particular attention to the debate related to the use of quantitative and qualitative analysis. The research utilises quantitative methods which are coupled with a mixture of qualitative research techniques such semi-structured interviews that aim to unveil hidden characteristics and likely causalities that are impossible to be identified by a quantitative analysis. The first part of the chapter illustrates the hypotheses to be tested and formulates the research questions. Part two, reviews the theoretical debates and philosophical assumptions that accompany the research methods. Part three includes a description of the quantitative and the qualitative methods used in this research. The final part of this chapter provides a detailed description of how this work has been conducted.

4.2 Hypotheses and research questions

The research aims to test several hypotheses related to venture capital activity in the UK regions and the role of the publicly backed VC funds in those activities. More particularly, it investigates the potential impact of publicly backed funds in the supply of VC finance to regional businesses and subsequently, it analyses how different to private venture capital funds these funds are, in terms of supporting innovation in businesses and consequently in regions.

In a research hypothesis, a single concept (e.g. type of venture capitalists – pubic or private) might explain others (e.g. innovation performance of business that they back or the extent to which venture capitalists interact with the outside world). The theoretical considerations result in an expectation about what should be observed if the theory is correct (Babbie 2004). The notation X=f(Y) is a conventional way of saying that X (business innovation or rate of interaction) is a function of (depends on) Y (extend of public dependency of the VC fund). At this level, X and Y still have rather general meanings that could result in different observations and measurements. But operationalization specifies the procedures that will be used to measure the variables and this operationalization process results in the formation of a testable hypothesis (Babbie 2004), such as:

''ability of the venture capital fund to invest in business with potential to innovate is a function of the type of money that it manages – public or private'', and

''self-reported frequency of interaction between venture capitalists and the outside word, is a function of the type of venture capital funds – public or private."

Observations aimed at finding out whether these statements accurately describe reality are part of what is typically called hypothesis testing (Babbie 2004).

For instance, given the large number of the publicly backed funds and the (collectively) large assets under management, it is likely that such funds *have become important players of the regional VC communities and in some cases dominate the regional VC landscape (Hypothesis 1).*

The literature suggests that there is a close relationship between venture capital and innovation (Gompers and Lerner 2000) and it is expected that this relationship (one of association and not causation) will be present at the UK regional level and *higher volumes of venture capital will be positively correlated with higher volumes of patents application (Hypothesis 2).*

Due to the fact that publicly backed funds have not performed well in terms of financial returns (NAO 2009) and the business that they backed did not show a noticeable improvement (NESTA and BVCA 2009), the expectation is that such funds *do not invest in companies with the potential to innovate to the same extent that private funds do (Hypothesis 3).*

There is a belief that publicly backed venture capitalists would be keener to engage with the regional innovation community than private venture capitalists, mainly due to their linkages with their funding bodies (e.g. Government, RDAs, Universities etc.). Therefore the hypothesis is that *professionals from publicly backed funds have established active communication and networking with several local incubators, Business Angel networks, universities and they appear to be more active than their counterparts from the private sector (Hypothesis 4).* Having set out these hypotheses, a number of questions for testing them were identified.

1. *Have the public funds changed the landscape of the supply of VC finance in UK regions?*
2. *Is a higher volume of VC investments positively correlated with higher volume of patent applications?*
3. *Are public funds less effective in investing in companies with the potential to innovate, than private funds?*

4. *Are those VCs employed by public VC funds more active in engaging with the regional innovation bodies than those who are employed by private VC funds?*

As a starting point, and common to research questions 1, 3 & 4 there was the need to identify which VC funds were publicly backed. In order to address question 4 it was also necessary to identify individual venture capitalists. Using the BVCA directory, commercial databases, venture capital funds websites, government websites such as BIS and Capital for Enterprise, and utilising personal knowledge of the market, it was possible to identify venture capital funds that receive public money. The questionnaire which was constructed for the purpose of investigating question 4 (see section 4.4.5), included questions that provided information on the proportion of public money that the fund had under management. Once the survey data was collected and analysed, such an expectation was clearly confirmed.

Since the four hypotheses can have more than two variables each (e.g. potential of business to innovate does not only depend on the type of VC it receives), it was necessary to identify other factors that may influence any potential relationship.

Based on the literature and also on discussions with several venture capital professionals, a number of possible factors that could influence the dependent variables were identified. For example, apart from the type of fund – public or private - the ability of a fund to invest in companies with the potential to innovate may be related to factors such as:

Industry focus - does the industry in which a VC fund invests have a close relationship to innovation (i.e. biotechnology) or not (i.e. retail sector). If the fund mainly invests in companies that operate in an industry that is not associated with innovation, then its potential to invest in innovation companies would be limited.

Location of the fund - does the region in which the fund operates have innovation bodies that are willing to engage with the VC activities; are the companies located in this region innovative (i.e. is there sufficient demand for VC investments). As shown earlier, the literature suggests that proximity is an important factor in the venture capital industry and therefore a VC fund is likely to make most of its investments in the region it is based. In addition, most of the publicly backed funds have geographical restrictions as to where they can invest. If the companies that are located in the region where the fund is based are not innovators, and there is no sufficient demand for VC investments, then the funds may find it hard to identify and invest in companies with the potential to innovate.

Average size of deal – Companies that operate in particular industries e.g. medical devices are in need of large investments. Funds that can only provide small size investments inevitably miss out all companies that require larger investments.

Investment stage – the stage of the investment could also be associated with innovation. Investments in early funding rounds entail more risk than those in later stages. Companies at later stages may have the ability to develop more innovation and create more patents.

In research question 4, the ability of a venture capitalist to engage and interact with the regional innovation community may be influenced by some of the factors outlined above, namely industry focus and location of the fund. In addition, other variables including years of experience in the firm, years living in the region, may also play an important role in the ability or willingness of the venture capitalists to interact with other bodies.

Years of experience in the firm - years of experience could be related to the rate of interaction, with professionals with more experience being more active than younger ones in interacting with external bodies.

Years living in the region - years of working in the same region could be related to the rate of interaction, with professional with more years living in the region being more active than professionals with fewer years.

Revenue – the company's revenue is an indication of the maturity of the firm. Therefore funds that invest in companies with little or no revenue take more risk than funds that invest in companies with revenues. As shown in the literature, pre revenue companies are in need of more active engagement from the venture capitalists side and may require more frequent interactions compared with more mature companies. It was not possible to distinguish between different stages of investments in the survey since the VCs indicate that invest in more than one investment stage. However, the variable revenue provides some indication as per the company's investment stage.

In order to ensure that several of these possible explanations are also taken into account when analysing information, an econometric analysis framework was adopted which allowed control for various alternative hypotheses.

4.3 Methodological approaches

From the 1980s onwards, economic geography moved away from traditional economic analysis and transformed into a more interdisciplinary approach using insights from social, cultural and political

sciences (Boschma and Frenken 2005). The quantitative revolution has been side-stepped and displaced by a more qualitative and speculative mode of analysis in the hope of representing the spatial scope and diversity of economic life. Thus while quantitative economic geography persists in the discipline, it is no longer the customary mode of analysis (Clark 1998).

Recent work in economic geography and the geography of finance is based upon in-depth interviews, or close dialogues with industry respondents (Clark 1998). Not all economic geographers use or even accept the use of close dialogue relative to stylized facts (a simplified presentation of empirical findings) and according to Clark (1998) this may prove to be a basic difference between geographers' economic geography and economists' economic geography. Clark (1998) argues that close dialogue can play an important role in promoting theoretical innovation in economic geography, in general, and in the geography of finance, in particular. He believes that the widespread acceptance of the market-efficiency hypothesis has led many researchers to ignore the spatial and temporal diversity of agents and institutions:

'' missing in the literature are explanations of apparent trends in local decision making, the process of product innovation in "thin" (incomplete and missing) markets, and an understanding of the interaction between the prejudices of investment institutions with respect to the urban economy in all its variety…Not surprisingly, the stylised facts claimed to be relevant to the geography of finance are so lacking content that cutting against their abstraction is one object of geographers' research'' (Clark 1998, p. 79).

Close dialogue is useful in this context because of the potential richness of substantive observation, the opportunity it promises for intellectual innovation, and its relative independence from the doctrine of market efficiency (Clark 1998). Close dialogue can be used, as it is used in the industry, to document and assess the actual practice of investment decision making, given the extraordinary variety of practice and the decentralized nature of market behaviour (Clark 1998).

Amin and Thrift (2000) note that economic geographers have developed their own skills base depending upon the understanding of open systems, appreciation of context, and qualitative techniques:

''*what is striking about the current state of the social science is the explosion of work on economics by scholars who either have left mainstream economics to found new domains of knowledge or do not have formal background in economics''* (Amin and Thrift 2000, p. 5).

"*Here the literature has moved well beyond formal models of technological innovation and learning into the territory of evolutionary and institutional economics, to identify the role of habits, routines, convention, path-dependencies, variety in the selection environment, and so on as key influence on the pace and direction of learning and adaptation in firms*" (Amin and Thrift 2000, p7).

Amin and Thrift (2000) argue that economic geographers have made a central contribution in their turn through their work on the effects of proximity, distance, and local context – on, what they call – the softer sources of innovation.

''*Without a feel for the processes and practices that sustain learning, there can be no proper theory of the firm and therefore also no proper understanding of the sources of economic competitiveness…Policy makers and practitioners are also turning to evidence-based economic research and to social, cultural and institutional understandings of the economy in order to stimulate innovation, entrepreneurship and competitiveness at varying spatial scales*'' (Amin and Thrift 2000, p. 8).

The debate between the different schools of economic geography - Neoclassical and Institutional Economics - has been nicely captured by Boschma and Freken (2005) who also provided support to an alternative school, the Evolutionary Economics. Neoclassical economists are renewing their interest in geography while geographers are moving away from economics (Boschma and Frenken 2005). The application of neoclassical economics in economic geography which was named New Economic Geography (see Krugman 1991) was seen as a revolutionary approach (Boschma and Frenken 2005). In his paper, ''Increasing returns and economic geography'', Krugman (1991, p. 484) suggests that:

''application of models and techniques derived from theoretical industrial organisation now allow a reconsideration of economic geography, that it is now time to attempt to incorporate the insights of the long but informal tradition in this area into formal models."

Krugman's approach can be considered as a recent extension of neoclassical thinking to explain trade, specialisation and agglomeration, relaxing the frequently used assumptions of perfect competition and constant returns to scale (Boschma and Frenken 2005). At the meantime the economic geographers, adapted an institutional approach arguing that differences in economic behaviour are primarily related to differences in institutions (Boschma and Frenken 2005). This has led to an extensive and inconclusive debate between geographers' and neoclassical economists' on the issue of the economic geography (Amin and Thrift 2000; Boschma and Frenken 2005). Some geographers dispute the relevance of general or even partial equilibrium models of spatial economic

systems, while recognising the commonalities of such models with analytical and mathematical techniques, there is a suspicion that analytical elegance and tractability drive the focus of analysis rather than the empirical problems (Clark 1998). At base, geographers dispute the plausibility of assumptions like homogeneous information, limited transaction and adjustment costs, and the presumption of spatial-economic convergence (Clark 1998).

The New Economic Geography and the Institutional Economic Geography differ in methodology they use. These differences are nicely captured by Boschma and Frenken (2005):

'' institutional economic geographers dismiss a priori the use of formal modelling and econometric specifications derived from these. Instead, they apply an inductive, often, case-study research approach, signalling out the local specificity of 'real places'. One of the objectives of institutional analysis is to understand the effect of the local specificity of 'real places' on economic development, which is mainly attributed to place-specific institutions at different spatial scales. Thus, an institutional approach takes differences between localities as the starting point of the analysis and analyses how place-specific institutions affect local economic development. In contrast, the New Economic Geography approaches the matter deductively using formal models assuming utility maximization and representative agents, and using equilibrium analysis to come to theoretical conclusions or predictions'' (Boschma and Frenken 2005, p.3).

Boschma and Freken (2005) suggest that Evolutionary economics can be considered a third approach in economic geography, yet it has not received much attention, perhaps due to the fact that economic geographers tend to refer to evolutionary economics and institutional economics as being more or less indistinguishable.

Table 3: Economic geography theories

Key issues	**Neoclassical**	**Institutional**	**Evolutionary**
Methodology	Deductive Formal modelling	Inductive Appreciative theorising	Both Both
Key assumptions	Optimising agent A-contextual	Rule-following agent Contextual (macro)	Satisficing agent Contextual (micro)
Conceptualisation of time	Equilibrium analysis Micro-to-macro	Static analysis Macro-to-micro	Out-of-equilibrium analysis/ Recursive
Geography	Neutral space Transport costs	Real place Place dependence	Neutral space --> real space Path dependence

Source: Boschma and Freken (2005)

The methodology that has been used in this thesis borrows elements from both schools – Neoclassical and Institutional - depending on the research questions aiming to answer. More particularly, to investigate Hypothesis *2 - higher volumes of venture capital will be positively correlated with higher volumes of patents application,* and hypothesis 3 - *publicly backed funds do not invest in companies with the potential to innovate to the same extent that private funds do* - equilibrium modelling has been used and in that respect, these sections follows neoclassical economic geographers. Econometrics has been widely used as methods of estimation and for the purpose of testing hypotheses (Babbie 2004). A basic concern in econometric analysis is the identification and measurement of functional relationships between the variables in question. The value of the dependent variable is related to a set of independent (or explanatory) variables by a function. However, influenced by the work of Clark (1998) and Amin and Thrift (2000) this thesis takes the position that the use of econometric techniques in the standard fashion cannot be expected to yield fruitful results when examining spatial proximities, interactions and the geography of finance. In these situations many things are going on at once and there is a lack of means which are open to many natural scientists to isolate particular processes in experiments (Sayer 2000).

Achen (1982) provides a guide on the use on regressions for social science. Since the survey chapter of this thesis (chapter 7) is concerned with the ecology of interactions and tries to examine a social phenomenon, it is appropriate that a regression style analysis should be interpreted within the framework of absence of statistical causality. Thus following Achen's suggestion, the aim of the regression is not to prove causality. In his book on interpreting regressions he notes:

"several different sets were described in a variety of ways until every other reasonable interpretation became improbable. There was no attempt at specifying the true functional form; it remained unknown and unwanted. Nor was any pretence made that the regression coefficient being estimated represented true effects constant across space and time. Instead the goal was to construct a statistical description faithful to the data set and to draw causal inferences from the overall pattern, not just from particular coefficients" (Achen 1982, p 29).

Good social data analysis oriented to theory construction usually begins with a non-functionally – specific hypothesis. A suitable data set is found to check the claim, and a substantively reasonable statistical description of it is constructed. If the original hypothesis proves consistent with the data, the researcher plays at being his or her own hardest critic by constructing plausible alternate explanations (Achen 1982).

Therefore, a more qualitative framework was adopted in order to test hypothesis 4 which looks at the ecology of interaction between venture capitalists and other bodies of the regional innovation system. Although econometric analysis is also used to analyse survey responses, it has been coupled with close dialogue with industry practitioners and a case study approach in accordance with suggestions from the institutional economic geography scholars.

4.4 Research design

The outline of the multi methods used for this research is set as follows: analysis of academic literature and the policy framework pertaining to the regional innovation and venture capital industry; collection and analysis of secondary data; econometric analysis; collection and analysis of primary data through a survey of individual venture capitalists; semi-structured and face to face in depth interviews with professional finance agents; and insights acquired from professional experience at NESTA.

4.4.1 Analysis of academic literature and the policy framework pertaining to the venture capital industry

The academic literature was gathered through searching library databases such as Scopus and BI/INFORM Global (Proquest) (accessed by Cardiff University website), Cardiff University library, Google Scholar and academic journals for which NESTA is subscribed to. The academic literature was supplemented by policy reports published by various organisations such as the European Commission, British Venture Capital Association (BVCA), European Venture Capital Association (EVCA), the British Business Angels Association (BBAA), the Department for Business, Innovation and Skills (BIS), the National Endowment for Science Technology and the Arts (NESTA).

4.4.2 Collection and analysis of data on the UK VC investments activity

This section outlines the sources of data used in chapter 5. Chapter 5 examines hypothesis 1, and aims to provide a detailed map of the investments activity in the UK regions, particularly the extent of publicly backed dependency of each region. The analysis of this chapter is based on two types of data, aggregated and disaggregated.

4.4.2.1 Aggregated data

Chapter 5, investments activity in the UK regions, draws on aggregated data at the national and regional level and on detailed records of investments deals. For venture capital activity data the annual reports on investment activity published by the British Venture Capital Association (BVCA)

have been used. This is based on a survey - undertaken by PriceWaterhouseCoopers - of the Association's members which comprise the vast majority of private equity and venture capital firms. It achieves a very high response rate, often 100 percent. The main limitation is that the statistics are reported in aggregate form, although are broken down into detailed categories, for example, by stage, industry and region.

4.4.2.2 Disaggregated data

In order to probe beyond the BVCA's aggregate figures the Library House data (now absorbed into Dow Jones Venture Source) has been utilised. The Library House database reports individual investments along with various additional information on the investor and business which enabled customised tables to be generated. The availability of such information on individual deals allows considerable flexibility in analysis. However, its coverage is restricted to publicly reported investments, with attendant limitations in information capture and classification. Using Library House database, a dataset of 4117 individual investments to 2359 UK based companies spread to all UK regions for the period 2000-2008 was created. The period covered in the analysis, 2000-2008 was determined by data availability.

It is important to note that Library House's coverage of investment activity is narrower than that of the BVCA, and in particular does not extend to private equity investments. In addition, its database is built up from reported investments and so does not capture all the investments that BVCA reports in its annual investments activity reports. In addition, the amount of information that is provided about each investment in Library House's database is limited, which restricts the amount of disaggregation possible. On the other hand, it does capture some investments, notably those by angel groups and high net worth individuals making large business angel investments, which are not included in BVCA investment statistics. However, there is no source which provides a comprehensive coverage of angel investments (Mason and Harrison 2008). Despite these data constraints, this thesis aims to bring an original perspective on the changing nature of the early stage venture capital market both by re-working some of the BVCA's published statistics and by combining the BVCA's statistics on investment activity with Library House's database. Using these sources it is possible to present a series of perspectives on different 'slices' of the market and specific details for the size and type of investments in each UK region.

The Library House database disaggregates the type of investments into two categories: First, those involving one or more private sector investors. This category primarily captures venture capital firms, but also identifies investments made by some types of Business Angels, notably investor networks (e.g. angel syndicates), family offices and named and un-named high net worth individuals.

On account of their size these investments are much more visible than those of typical Business Angels. However, a key limitation of the data is that investments by Business Angels are only identified where they have co-invested with either private or public sector funds. Second, those involving one or more publicly backed funds (e.g. Regional Venture Capital Funds, University Challenge Funds). These are funds which have received some or all of their capital from the public sector, including central government departments, regional development agencies and the European Union (e.g. ERDF). They are normally managed by independent fund managers.

This information has allowed for the classification of investments into the following three categories: First, deals involving solely private sector investors. This includes both venture capital funds and Business Angels. Second, deals solely made by publicly-backed funds. Third, deals - which are termed as *co-investments* here - in which one or more private sector investors has invested alongside one or more public sector funds. Investments in this category include both *ad hoc* syndications between public sector funds and private investors, and also investments involving Co-Investment Funds that have been established specifically to invest alongside private investors (Figure 13)

Figure 13: Study Sample

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Year of investment	4117	2004	2.44	2000	2008
Size of deal	3173	2978.14	5454.03	4	60000
Number of round	4117	1.85	1.21	1	10
Type of investments					
Solely public investments	4117	0.16	0.36	0	1
Solely private investments	4117	0.64	0.48	0	1
Co-investments	4117	0.16	0.36	0	1
Business Angels investments	4117	0.17	0.37	0	1

Source: Library House database and author's research

The analysis of this data in chapter 5 is graphically presented using tables and bar charts with stacked columns which compare the contribution of each value to a total across categories by using vertical rectangles. By aggregating the individual deal level data by region, it was possible to capture specific characteristics of the regional VC markets such as stage, sector and finance source preferences. The same data is also used in chapter 6 in an econometric analysis framework.

Defining early stage investments

A lack of consistency in definitions is one of the primary reasons for the lack of consensus about the scale of early stage investment activity. The British Venture Capital Association (BVCA) defines the

early stage into two sub-categories: *start-up*: financing provided to companies for product development and initial marketing. Companies may be in the process of being set up or may have been in business for a short time, but have not sold their product commercially. O*ther early stage*: financing provided to companies that have completed the product development stage and require further funds to initiate commercial manufacturing and sales. They will not yet be generating a profit.

The European Venture Capital Association (EVCA) definition of early stage separates the seed stage from the start-up stage to create an additional sub-category. *Seed capital* is defined as financing provided to research, assess and develop an initial concept before a business has reached the start-up phase.

Library House classifies its investments in terms of financing rounds rather than stages of finance. However, it does identify companies at the product development stages, defined as companies that have produced prototypes with a product being improved for commercialisation.

A limitation of these definitions is that they do not take account of the amount invested. The 'equity gap' concept includes both stage of investment and size of investment components. Government regards the upper limit of the equity gap to be £2m (HM Treasury 2003). Therefore for the purpose of this analysis early stage investments are defined as investment made for less than £2m in funding rounds 1, 2 and 3.

4.4.3 Investigating the relationship between venture capital and innovation

In order to investigate the relationship between VC and innovation (hypothesis 2) there was a need to conceptualise the meaning of innovation and identify measurable values that can be assessed against venture capital activity. As examined in chapter 2, the literature suggests that there are a number of factors that contribute towards the improvement of innovation performance of a country or a region such as increases in business and government R&D expenditure, employment in R&D and production of patents.

Data analysis

In order to examine the relationship between venture capital and innovation, the number of patent applications and the business R&D expenditure were identified as proxies for the volume of innovation. A patent application may suggest that the business has the potential to get a patent. In addition, a patent application is the preferred proxy rather than a patent grant, since there might be a significant time lag between filing an application and receiving a grant (Hall et al. 2001). At the

aggregated level, data related to the performance of the 12 UK regions over a 12 year period (1995-2007) has been explored using data from the European Patents Office for the number of patent applications, and data from the Office of National Statistics (ONS) and EUROSTAT for the R&D expenditure data.

The data is analysed at two levels, space and time. First, the analysis aims to test whether time has an impact in the relationship between VC and innovation – in other words, whether the relationship changes according over time. Second, it aims to examine whether space plays any role in the relationship - whether the differences over time are also related to location. The region fixed effects model is used in the examination of the relationship between VC and innovation in order to identify space-invariant factors such as the industrial specialization of individual regions. It is important to note this analysis does not prove causality (see Achen 1982). As Achen (1982) suggested, in social science, it is appropriate that a regression style analysis should be interpreted within the framework of absence of statistical causality.

"Functionally correct casual specification in social science is neither possible nor desirable. Social scientists neither have nor want correct, stable functional forms for their explanations. Good social theory avoids such things" (Achen 1982, p. 16).

Correlation coefficients between venture capital and several innovation related indicators such as government R&D expenditure and employment in R&D are also provided in the analysis.

4.4.4 Examining the relationship between the potential of a business to innovate and the type of venture capital investments

To examine the relationship between the potential of a business to innovate – expressed as the company's possession of a patent or a patent application - and the type of venture capital investments it receives – public or private - data must be available for a wide range of industries, regions and be comparable across years. BVCA provides only aggregated data, so it does not allow to unveil particular characteristics of the deals such as name of company that received finance, stage and source of finance and industry focus or whether they received a patent or not. Hence, in order to perform the analysis, disaggregated data has been collected from two sources i.e. the Library House database and that of the Patent Office.

Dependent variable

As discussed earlier, patents grants or patent applications have been widely used by scholars as proxies for innovation (see Ueda and Hirukawa 2006, Hirukawa and Ueda 2011). Using the EPO

online search facility which is integrated in the UK Patents Office website, it was possible to identify individual companies that have been granted or applied for an EPO patent. Matching the Library House database with the EPO database, it was possible to check which of the 2359 companies that received one or more of the 4117 individual VC investments had received or applied for a patent.

Explanatory variables

Similarly to chapter 5, investments made by publicly backed funds, private funds and Business Angels were identified. Investments made by publicly backed funds were then grouped into two categories: investments made by solely public funds, and investments made by a syndication of public and private funds (co-investments).

Solely public investments are investments made to companies solely by publicly backed funds (in syndication or alone). Co-investments are investments made to companies by a syndication between a publicly backed fund and a private fund. It is worth noting that it was not possible to identify who was the lead investor in each syndicate. Business Angel are syndicate venture capital deals in which a Business Angel individual or network has participated in (since it was not possible to collect data for investments made solely by Business Angels).

Control variables

Data for a number of control variables were collected: Size of deal indicates the size (in British pounds) of the investment made to the company. Number of round is the number of the funding round that the investment took place. Regional dummies are dummies that take the value 1 if the company that received the investment is located in a particular region and 0 otherwise. Industry dummies are dummies that take the value 1 if the company that received the investment operates in a particular industry, and 0 otherwise. Year dummies are dummies that take the value 1 if the investment took place in a particular year and 0 otherwise (Table 4).

Table 4: Description of variables

Variable	*Description*	*Source*
Patents	Dummy that takes the value 1 if the company has a patent or has applied for one, and 0 otherwise	EPO
Solely private investments	Dummy that takes the value 1 if the deal is made solely by one or more private funds	Library House, desk research
Solely public investments	Dummy that takes the value 1 if the deal is made solely by one or more public funds	Library House, desk research
Co-investments	Dummy that takes the value 1 if the deal is a syndicate between a public and a private fund, or a public fund and a business angel	Library House, desk research
Business Angels	Dummy that takes the value 1 if a Business Angel or Business Angel network has participated in the deal	Library House

Deal size	A measurement of the size of the deal	Library House
Number of round	An ordinal variable indicating the number of funding round when the deal took place (1-9)	Library House
Regional dummies	Dummies that take the value 1 if the company that received the investment is located in a particular region and 0 otherwise	Library House
Industry dummies	Dummies that take the value 1 if the company that received the investment operates in a particular region, and 0 otherwise	Library House
Year dummies	Dummies that take the value if the investment took place in a particular year and 0 otherwise	Library House

Statistical analysis

Regression analysis is commonly used in research on venture capital (see Kortum and Lerner 2000; Lerner et al. 2005) aiming to measure the likely impact of venture capital in innovation as shown in the literature review. Following these steps, the current research employs a set of regression techniques. All regressions have been performed using the statistical software STATA.

Ordinary Least Squares (OLS) and Probit models are used in the examination of the relationship between the type of venture capital (public or private) and innovation expressed as the innovation outputs of the firm (patent applications). In this case the dependent variable indicates whether a company has (or has applied for) a patent (regardless of the time of the investment). Such answers are transferred into the number 0 and 1, where 0 is equal to a company without a patent or patent application and 1 is equal to company with a patent or patent application. In statistical terms such variables are Bernoulli variables. Therefore the chosen model used is a Binomial statistical model. This assumes that the trials are independent. In other words, the fact that one company has a patent does not influence whether another company has a patent or not. Hypothetically, a company may seek to receive patent because its competitor has one. However in this study it was not possible to investigate this hypothesis and therefore it was assumed that the trials are completely independent from company to company. There are two types of binomial models, logistic and probit. Both models have been used in this study and the results are similar. Therefore only probit regression results are reported.

4.4.5 Collection and analysis of primary data through a survey of individual venture capitalists

In quantitative research the hypothesis is deduced from the theory and is tested (Bryman 2004). However, with cross-sectional designs of the kind used in most social survey research, there is an ambiguity about the direction of causal influence in that data concerning variables are simultaneously collected.

''A criterion of good quantitative research is frequently the extent to which there is confidence in the researcher's causal inferences. Research that exhibits the characteristics of an experimental design is often more highly valued than cross-sectional research, because of the greater confidence that can be enjoyed in the causal findings associated with the formed" (Bryman 2004, p. 21).

Therefore, in this analysis a dataset is used that has been collected from a survey in order to conduct econometric analysis which reveals the extent of confidence in my findings.

4.4.5.1 Identifying the study sample

The data collected for this study included responses to a questionnaire from 50 different venture capitalists and multiple interviews with 10 venture capitalists, lawyers and other finance practitioners.

The venture capitalists were geographically dispersed across the UK and in a variety of industries. In order to minimise sample bias each venture capitalist was asked to fill out the questionnaire for the fund that he or she is most heavily involved in (GPs often manage more than one venture capital fund). The survey was restricted to venture capitalists that mainly invest in seed and very early stage companies. This allowed the research to focus exclusively on the interactions of the key individuals within the early stage technology venture capital community and to control for the variations on the findings that the inclusion of other sectors might have caused (e.g. retail sector).

As a starting point, 48 early stage venture capital funds were identified and the employees from 43 of them were contacted. Those funds contacted met the criteria of being sufficiently sized, active in the last three years, focused on high tech innovative companies and invest in seed, start-up, early growth, late growth and expansion stage. Five funds were either closed or too small (i.e. less than £5m). Using desk research (internet, brochures and the BVCA directory) 309 individual venture capitalists that worked in these 43 early stage venture capital fund were identified. These funds are specialised in high technology and innovative ventures and are members of the British Venture Capital Association (BVCA). Correct and update details were acquired for 273 of them. A list of the funds that took part in the survey together with copy of the questionnaire can be found in Appendix II.

The questionaire itself was developed in three stages. In the first stage two academics were consulted and asked to provide feedback on the draft questionnaire. At a second stage, the revised questionaire was presented to five venture capitalists and similalry, their feedback was provided. During this process several questions were changed or added. When the questionnaire was ready two venture capitalists were asked to complete it and provide feedback.

The questionnaire was sent out via personalised emails in an electronic format. The survey was completed in four stages, the first stage took place on 8-9 July 2009, the second stage on 15-16 July 2009, the third on 22-23 July 2009 and a final reminder was sent out on the 27th July 2009. This was then followed by a number of personal telephone calls to various selected individuals to encourage them to complete the survey or forward the questionnaire to the appropriate person at the fund.

During the survey completion, some individuals were reluctant to answer the questions, either because they did know the answers to some of the questions or thought that they did not need to complete the survey because a colleague of them completed it already on behalf of the VC fund. Indeed, several emails were received stating that the answer to the survey represented all the staff from the fund.

Table 5: Response rate

	Value	**Percentage**
Total number of people identified as relevant to complete the survey	368	
Total number of people contacted	309	100.00%
Total number of valid email addresses	273	88.35%
Total number of responses related to the number of people contacted	52	16.8%
Total number of responses as a percentage of valid email addresses	52	19%
Total number of fully completed responses	50	

The response rate of completed questionnaires is 19 percent (Table 5). Due to the sensitivity of the industry the questionnaire was completed on an anonymous basis however, participants were invited to complete the name of their fund and their job title and a few of them did. Therefore, it is known that venture capitalists from at least 20 named venture capital funds took part in the survey (49 percent of contacted funds). The remaining 30 questionnaires were completed by venture capitalists from different or the same funds. Therefore, the response rate of 19 percent of the venture capitalists contacted represents a much larger sample of the contacted individuals and at least 49 percent of the venture capital funds that were contacted and currently operate in the early stage market and invest in high technology and innovative companies.

It is worth mentioning that it is commonly acknowledged that people in the venture capital and private equity industry are reluctant to provide information about their funds related activity due to high level competition and the sensitivity of the issue. Indeed, some of the interviewed venture capitalists were surprised with the number of the completed surveys received saying that *"this is a very good response if you think that venture capitalists do not normally reply to this type of survey due to their workload and sensitivity of the issues"* (interviewed venture capitalists).

The responses collected were transformed into numbers and in order to be analysed using SPSS and STATA (statisatical softwares).

Once the field work was completed, multiple meetings with 10 venture capital managers and other professionals were arranged to discuss the findings of the survey and to investigate the likely cause of some surprising results. This was a very revealing process that allowed for more in-depth interrogation of some of the more puzzling findings of the survey. Quotes from these interviews have been used on various occasions to support the numerical findings.

4.4.5.2 Descriptive statistics and sample bias control

In order to check whether the sample generated is representative of the population of UK early stage venture capitalists in 2009, a number of tests were conducted. First, the study sample was compared with the population on two characteristics, geographical distribution and size.

Geographical coverage

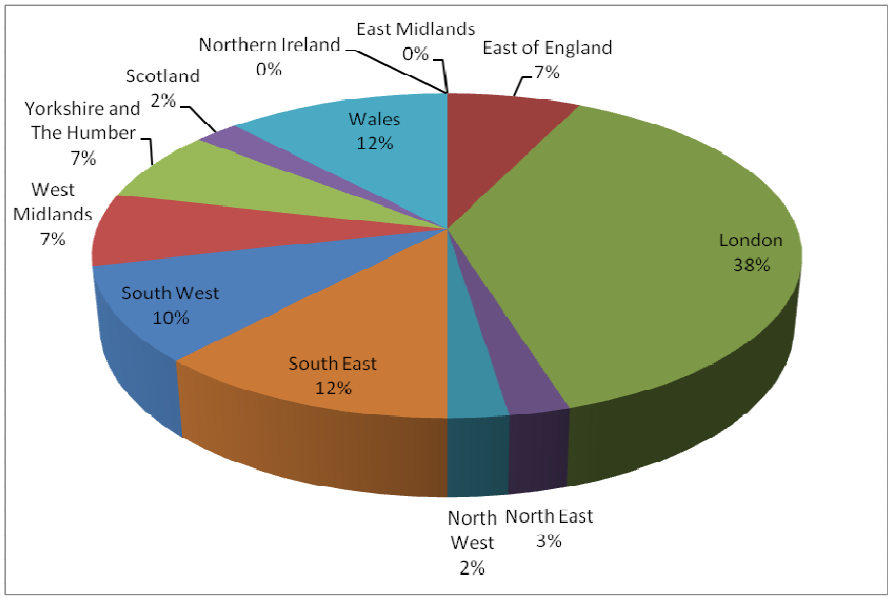
Table 6: Geographical representation of the sample

Early stage (2008)	Amount invested (£m) BVCA	%	No of responses in the study sample	%
South East	64	18%	5	11%
London	172	48%	18	38%
South West	12	3%	4	9%
East of England	20	6%	3	6%
West Midlands	12	3%	4	9%
East Midlands	9	3%	0	0%
Yorkshire	5	1%	3	6%
North West	23	6%	2	4%
North East	10	3%	1	2%
Scotland	24	7%	2	4%
Wales	2	1%	5	11%
Northern Ireland	7	2%	0	0%
	360	100%	47*	100%

* 3 venture capitalists did not indicate the region they are based

BVCA data was used to measure the proportion of amount invested in each UK region in 2008. The results are illustrated in the third column of Table 6. The last column of the table illustrates the proportion of responses by each UK region. With the exeption of Wales which has provided more responses than expected (perhaps due to personal links) the percentages between the two proportion columns do not significanly vary. In order to minimise bias in the geographical sample , two responses from Wales were randomly excluded. For a Chi-square goodness of fit analysis please see Appendix III. The geographical distribution of survey responses is graphically presented in Figure 14.

Figure 14: Regional coverage



*5 respondents did not indicate any region

Size

Potential selection bias in the reporting of sizes in the sample was also checked. In order to control for the size of the funds in the study sample, the Thomson Reuters VentureXpert database was used to capture the size variance of the funds which share similar characteristics with the funds in the study sample. The funds selected met the following criteria: invest in seed, ealry stage, expansion and later stage, based in the UK, being active during the last three years and invest in the following idustries communication and media, computer hardware, computer software and services, internet specific, semiconductors, biotechnology, medical/health, consumer related and industrial energy.

Table 7: Size of the funds in the sample

Fund size	No of funds in the study sample	%	No of funds in VentureXpert	%
Up to £30m	20	43%	18	44%
£31m-£50m	12	26%	8	20%
£51m-£100+*	15	32%	15	37%
Total	47		41	

* For the VentureXpert dataset analysis only funds that invested between £51-£150m were captured

Table 7 shows summary statistics for the distribution of the size of venture capital funds in the study sample and the population. The third column illustrates the proportion of funds by size in the study sample (47 completed questionnaires contained information about the size of the fund). The final column of the table illustrates the proportion of fund by size contained in the commercial database VentureXpert Thomson Reuteurs (whish is representative of the total population). It is clear that the size fund variation of the study sample does not signifiantly vary from the total population expressed using a commercial database.

The average size in the Venturexpert database does not appear to differ systematically from the fund sizes in the study sample. It can be easily observed that the characteristics of the two distributions are quite similar and it is concluded that the study sample is by and large representative of the population of UK early stage venture capital fund managers.

4.4.5.3 Variables

This subsection describes the main variables and the way they are defined and collated.

Public_funds: is a dummy variable that takes the value 1 if the venture capitalist is employed by a VC fund that receoved more than half of its assets from public money (example of such funds: Scottish Enterprise, Advantage Early Growth Ltd, Finance Wales etc) and 0 otherwise.

Private_funds: is a dummy variable that takes the value 1 if the venture capitalist is empoyed by a VC fund that receive no public money at all and therefore we call them private funds (such as Index and Eden)

Partnership_funds: is a dummy variable that takes value 1 if the venture capitalist is employed by a VC fund that receive the minority (1-49 percent) of its assets from the public sector (such as Enterprise Ventures Ltd and WME).

Fund_size: measures the total size of each fund

Portfolio_companies: measures the extent of interactions between the venture capitalists and their portfolio companies. It can take the following values (1= "never", 2= "hardly ever - once a year at most", 3= "occasionally – a few times a year", 4= "regularly – once a month", 5= "often – more than once a month", 6= "very frequently – at least once a week").

Similarly the following variables measure the extent of interactions between the venture capitalist and the various bodies: *Companies outside your porfolio; Other private venture capital funds (within your region); Other private venture capital funds (outside your region); Other publicly backed venture capital funds (within your region); Other publicly backed venture capital funds (outside your region); Business Angel networks (within your region); Business Angel networks (outside your region); Business Angel individuals; Banks; Universities with no flexible IP policy; Universities with flexible IP policy; Regional R&D institutes (if not universities); RDAs (when applicable); Other public regional bodies (e.g. endowments, councils etc); Regional authorities, Law companies, Specialists (e.g. experts in a particular technology); Community organisations and charities; Managers of technology parks or incubators; Companies based in technology parks or incubators; IP protection bodies; Investment forums organised by private bodies; Investment forums organised by public bodies; Networking events organised by private bodies; Networking events organised by public bodies; Internet forums and blogs*

Revenue_sales: measure the proportion of company portfolio that had revenue sales at the time of investment

Time_in_region: measures the duration of the venture capitalist residence in his region and

Time_in_company: measure the length of employment within the venture capital fund

Named funds and job titles

51 percent of the respondents did not disclose their job title, while 62 percent of them disclosed the name of their fund. From the disclosed information provided, it is apparent that at least 20 different funds took part in the survey (Table 8).

Table 8: List of responders

	Fund	**Job title**
1	Enterprise Ventures Ltd	CEO
2	YFM Group	Investment Manager
3	Finance Wales	Investment Director

4	Creative Advantage Fund	Non exec Director
5	NESTA	Investment Manager
6	NESTA	Investment Director
7	NESTA	Business Development Director
8	Eden Ventures UK Ltd	
9	NorthStarr Equity Investors	Investment Manager
10	Sigam Capital Group plc	Investment Director
11	Index Ventures	
12	WME	Investment Manager
13	PUK Ventures	
14	Finance South East	Fund Manager
15	London Technology Fund	Chairman
16	South East Growth Fund	Fund Principal
17	Cre8Ventures (NASDAQ:MENT)	European Director
18	TTP Ventures	Associate
19	Finance Wales	Fund Manager
20	Finance Wales	Strategy and Communication Director
21	Seraphim Capital	Investment Manager
22	Viking Fund	Managing Director
23	Hafren Ventures LLP	Partner
24	Abingworth LLP	Principal, Science & Technology
25	Avlar Bioventures Ltd	Director

4.4.6 Semi-structured and face to face in depth interviews with professional finance agents

A number of interviews with industry professionals have been conducted in order to discuss with them the findings of the survey. The first set of interviews with two venture capitalists took place in June 2009, in order to discuss the survey questions. The questions were emailed to them in advance of the interview meetings in order to allow sufficient time to study the questions and identify potential gaps. During the interview meetings, several suggestions were made on how to improve the questionnaire with the aim to make it easily readable by the venture capitalists.

A second set of interviews with a small group of VC professionals took place sporadically during 2009. All interviews were semi structured: a small number of questions were prepared in advance of the meeting but the interview often led to a discussion of the overall situation in the VC market in the UK (Table 9).

All findings from the research were presented to the VCs and specific questions were directed to different people. For example, the survey saw that publicly backed funds interact much more often

with law firms than the private funds. This finding was presented to a professional from a law firm that is specialised in VC investments and his response is included in the analysis.

Table 9: Names and organisation of professionals that have been interviewed

1	Ivan Griffin, NESTA Investments
2	Libby Kinsey, NESTA Investments
3	George Whitehead, NESTA Investments
4	Anthea Harrison, Independent VC consultant
5	Alex Hook, NESTA Investments
6	Hugh Gardner Marriot Harrison Law Company
7	Mark Fenwick, Public VC Fund Manager, North East
8	Iain Wilcock, NESTA Investments
9	Nick Moon, Finance Wales
10	Meirion Thomas, CM International

4.4.7 Insight knowledge of the market through personal work experience

Working almost 4 years for NESTA, one year full time and three years part-time, has allowed me to acquire first hand professional experience of the venture capital industry. My association with NESTA has allowed me access to expensive commercial databases that may have been difficult to acquire otherwise. In addition, throughout my time with NESTA I established a network of venture capital professionals whom I mobilised for the purpose of my thesis.

However, my association with NESTA also raised concerns to some of the survey participants. More particularly, many of the funds that were included in the survey see NESTA as a direct competitor, therefore several venture capitalists where sceptical when I first approached them. I provided them with reassurances that all the survey responses will be anonymous and all their feedback will be used solely for research purposes and will not be shared with my NESTA colleagues. In addition, I used my university email account for all my email correspondence associated with the survey in order to provide evidence of my position as an independent PhD student.

4.4.8 Case study approach

The region of Wales represents an interesting example of a region heavily dependent on public sector, which is also reflected in its regional innovation system and its financial system. Aiming to identify similarities and differences between privately and publicly led regional innovation systems,

the region of Wales was selected as appropriate comparative case study to illuminate further the key findings of the research.

Wales has been at the forefront of regional development theories during the last decade and it has been a pioneer of regional innovation systems and policy approaches. This case study aims to highlight the role of the public venture capital community in Wales and to identify similarities and differences with privately led venture capital communities. This helps to illuminate some of the key findings from the thesis concerning the role of publicly led venture capital activity at a regional level and the ecology of interaction between the innovation and the venture capital community within a public oriented regional innovation system.

The case study considers the regional innovation environment and the economic and policy context within which the Welsh venture capital community operates. It provides a historic overview of the development of the VC industry in Wales. It also compares the main characteristics of the Welsh venture capital market with those in privately and publicly led venture capital markets. Finally, it provides some policy recommendation related to the development of the venture capital market in Wales. Learning points derived from the Wales case have relevance to other publicly oriented regional innovation environments and in the effective provision of publicly backed venture capital finance.

4.5 Conclusion

In recent years there has been a growing convergence between students of economic geography and students of innovation; the former are becoming more interested in innovation capacity as a way of explaining uneven regional development, while the latter are no longer so impervious to spatial considerations in their work on technological change (Morgan 1997, p. 494).

By adopting a mixture of research methodologies, including quantitative and qualitative research techniques, this thesis aims to contribute to the ''*growing confluence between economic geography and innovation studies which creates a potentially significant research agenda with respect to the interactive model of innovation and the role of institutions and social conventions in economic development''* (Morgan 1997, p. 500).

This chapter has presented some of the theoretical debates that accompany the mainly quantitative research methods employed in this research. It has also provided a detailed description of the research design, the methods used and the way in which the research was undertaken. The next chapter now proceeds to the analysis of the venture capital activity at the UK regions.

5 CHAPTER 5: VENTURE CAPITAL ACTIVITY IN UK REGIONS

5.1 Introduction

The aim of this chapter is threefold: first, to provide a detailed empirical picture of the supply of early stage venture capital; second, to update earlier evidence on the uneven geography of venture capital in the UK (Mason and Harrison 2002a); and third, to probe below the aggregate statistics provided by the British Venture Capital Association using deal specific information to highlight regional variations in the composition of venture capital. By doing this, it examines the involvement of publicly backed funds in the VC market and their contribution in the supply of VC finance at the regional level. This chapter addresses two empirical questions: first, does the geography of venture capital investment in the UK continue to be characterised by regional inequalities, as previous studies have indicated (Mason 1987; Martin 1989; Martin et al. 2002; Mason and Harrison 2002a)? And second, what has been the effect of the changes in the supply of venture capital, as described in chapter 3 , on the geography of venture capital investments? The answers to these questions will, in turn, inform the first research question of the thesis: *what has been the effect of the increased government intervention in the supply of venture capital on the geography of venture capital in the UK in the early 21st century?*

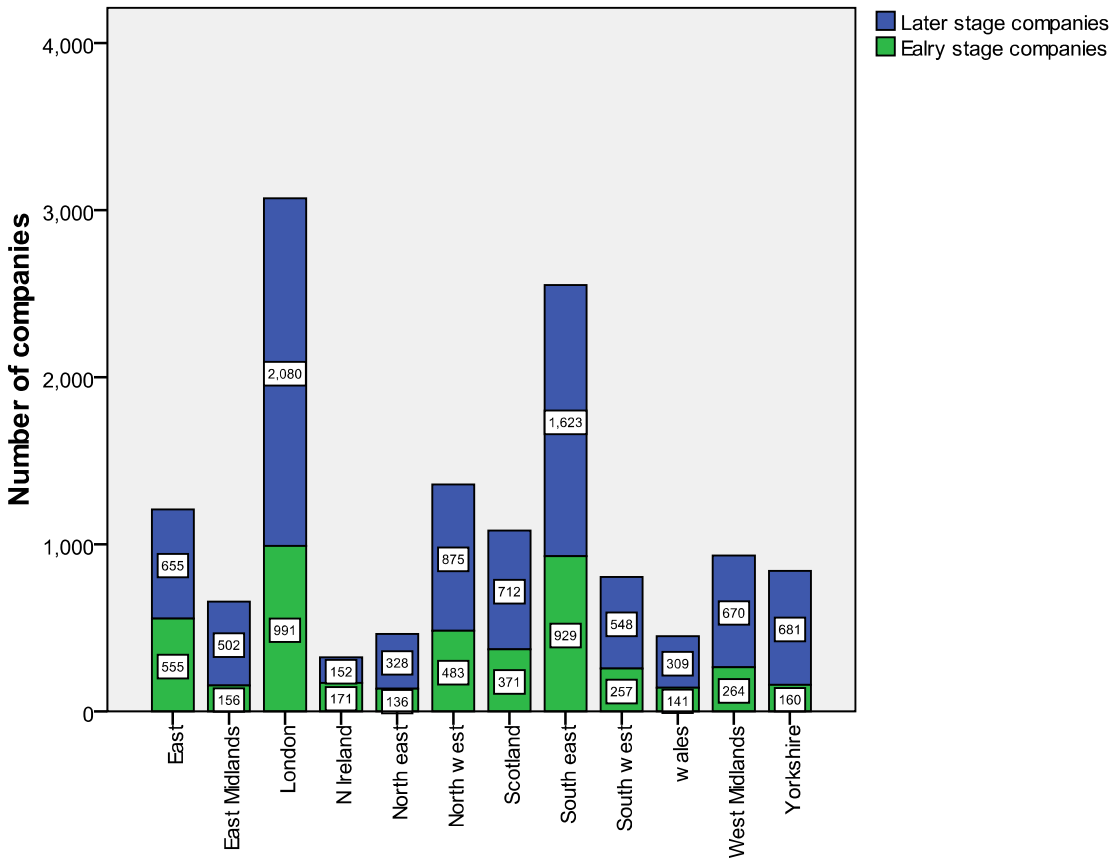
Several observations have emerged from this analysis mainly related to the wide heterogeneity between the UK regions in terms of VC activity and the extent of public intervention. The regional dimension of the analysis is therefore of special interest as it is the first comprehensive analysis of the source of VC investments (public or private) for each UK region. This chapter provides a regional perspective on VC literature that to date has been primarily focus on the country level (with the exception of the U.S), and contributes to the literature on the role of government in fostering venture capital activity by examining the investments and source of finance in the UK and its regions. Perhaps the most important contribution is the investigation of the relationship between the type of VC funds (private or public) and the investment activities in which they are engaged. The data allows the relations between private and public VC investments to be compared across regions and therefore brings some light into the underdeveloped literature on the regional variations in venture capital markets.

5.2 Venture capital trends in the UK regions

It is well established that venture capital is not equally available in all parts of a nation (Florida and Kenney 1988; Mason and Harrison 2002a; Zook 2002; Martin et al. 2005). The uneven geography of venture capital investing is typically explained as an outcome of the clustering of venture capital funds in a small number of cities, and the localised nature of venture capital investing as a means of reducing uncertainty and thereby minimising risk (Florida and Kenney 1988; Sorensen and Stuart 2001; Mason 2007). Venture capital firms do make long distance investments, particularly as they mature (De Clercq et al. 2001; Sorensen and Stuart 2001), but this is normally in the context of syndicated investments with one or more other investors, and where one of the other investors – usually the lead investor - is local to the investee business (see Rosiello and Parris 2009 on the UK biotechnology sector).

Several UK government interventions have specifically focused on the 'regional equity gap' with initiatives designed to increase the supply of venture capital in specific regions and localities (Murray 1998; Sunley et al. 2005). Not everyone is convinced of the need for government intervention to increase the supply of early stage venture capital. Indeed, there are inherent difficulties in differentiating between deserving companies unable to access finance because of market inefficiencies, and those that cannot raise finance because they fail to meet appropriate investment criteria; the latter simply reflects the effective operation of the market. Moreover, many private sector venture capital fund managers are critical of the investment objectives of publicly backed funds and the quality of their management (Almeida 2005).

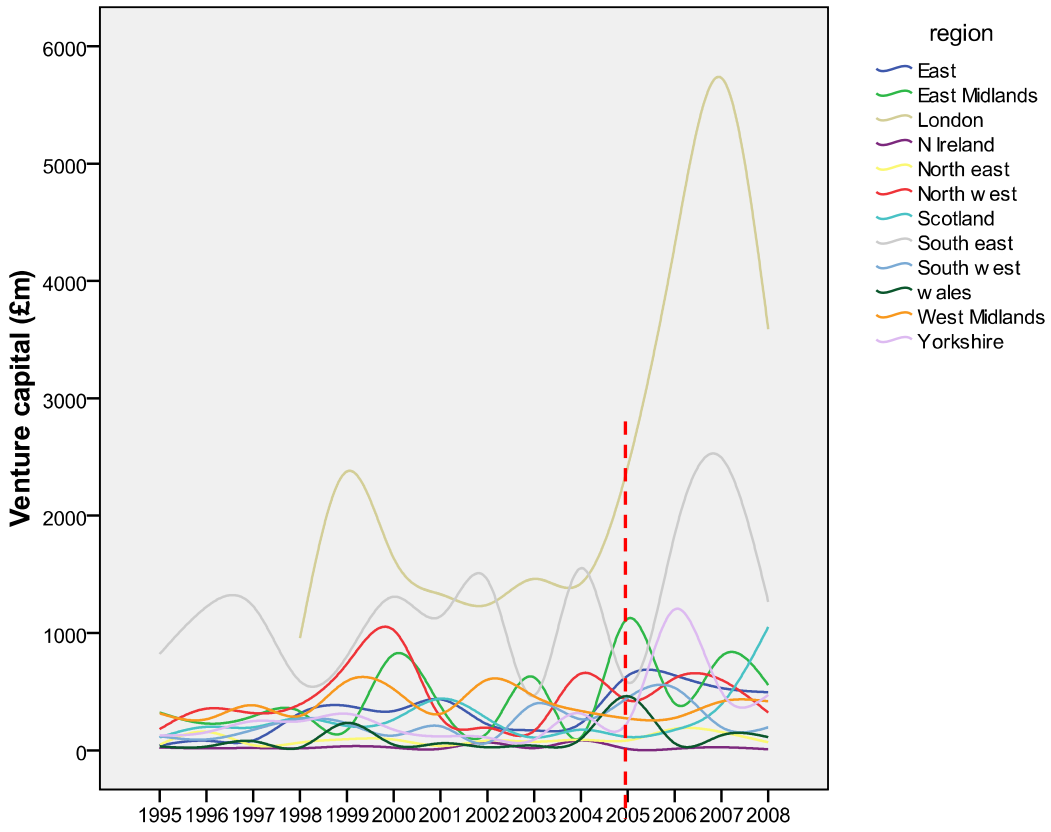
Figure 15: VC backed companies by region and by stage, 1998-2008



Source: BVCA various investments activity reports
^ Investment stage breakdown is only available since 1998 in the BVCA data

Figure 15 provides a graphical presentation of the VC activity, expressed as the number of VC backed companies, in the UK regions for the period 1998-2008. The data is broken down into early stage and later stage companies. Unsurprisingly, London and South East have the higher number of VC backed companies from which approximately one third was early stage companies. North West, East of England and Scotland are also home to relatively high number of VC backed companies.

Figure 16: Venture Capital amounts invested by region, 1995-2008



Source: BVCA various investments activity reports

Figure 16 illustrates the total amounts invested in VC backed companies during 1995-2008 in all UK regions. During the period 1995-2005, companies based in London and South East received more investments compared with other regions but several regions were not far behind. Since 2005, London experienced a large increase in the VC amounts invested while the remaining regions (with the exception of South East) did not experience such a trend. This begs the question of what may have caused the underlined increase in investments disparities between the UK regions since 2005.

5.2.1 The distribution of risk capital investments in the UK regions by stage

The distribution of risk capital amongst the UK regions was previously analysed by Mason and Harrison (2002a). Mason and Harrison examined risk capital activity in the UK regions for the period from 1985 until 2000 and they concluded that the regional concentration of risk capital investments has been considerably reduced since the 1980s. They argued that this shift towards a less unequal regional distribution was driven by the private equity (or "merchant venture capital" as the call it) rather than venture capital (or "classic venture capital") investments.

Table 10 illustrates the regional proportion of risk capital cumulative amounts invested in the UK regions for the period 1985-1991 & 1992-1998 (as calculated by Mason and Harrison) and 1999-2007 (as calculated using BVCA data).

Table 10: Proportion of cumulative invested risk capital by region, 1985-2007

Region	1985-1991	1992-1998	1999-2007
London & South East	53.00%	42.50%	54.80%
South West	5.60%	6.00%	4.30%
East of England	3.10%	3.10%	6.10%
West Midlands	6.90%	10.30%	6.40%
East Midlands	6.60%	8.60%	7.70%
Yorkshire	5.90%	6.20%	5.20%
North West	4.40%	10.90%	8.00%
North East	3.30%	2.80%	1.50%
Scotland	8.70%	6.70%	3.80%
Wales	2.00%	1.80%	1.80%
Northern Ireland	0.50%	0.90%	0.50%
Total	100%	100%	100%

Source: Mason and Harrison 2002a and BVCA reports, various years

* Table includes all private equity investments and not just venture capital investments

In the first reporting period, 1985-1991, companies located in London & the South East received the majority of all private equity investments in the UK (53 percent). Scotland received 8.7 percent, West Midlands 6.9 percent and East Midlands 6.6 percent. In contrast, companies located in Northern Ireland only attracted 0.5 percent of all investments made to all UK companies during that period.

During 1992-1998, London and the South East reduced their share of investment by over 10 percent compared with the previous reporting period and accounted for 42.5 percent of all investments made. North West companies received 10.9 percent, West Midland 10.3 percent while Northern Ireland almost double its proportion of invested amount received compared with the previous period, from 0.5 to 0.9 percent.

In the most recent reporting period (1999-2007) however, London and the South East experienced an increase of 12.3 percent (from 42.5 to 54.8 percent) and East of England almost doubled its share from 3.1 percent for the period 1992-1998 to 6.1 perent. All the remaining regions – with the exception of Wales which sustained its share – experienced a decrease in their share of risk capital

investments compared to the previous reporting period. In fact, the West Midlands and Scotland have significantly decreased their proportion of risk capital, 10.3 to 6.4 percent and from 6.7 to 3.8 percent respectively.

It is clear that there has been an increase in the regional disparities amongst the UK regions during the last decade. The regional distribution of risk capital in the period 1999-2007 has significantly changed since the period 1992-1998 and is now back to the 1985-1991 levels. It seems that the progress towards narrowing the regional distribution gap experienced in the previous decade (1992-1998) is well over. The disaggregate analysis in the following table provides some useful insights as to the type of the investments that are responsible for these changes and mainly the shift of investments towards London and the South East. Details on investments are broken down by date and investments stage and are only available since 1998 from BVCA. Therefore it is only possible to investigate the changes by investments stage since this year. The examining period is split into two "sub periods" of five years (1998-2002 & 2003-2007) in order to clearly observe the changes that occurred.

Table 11: Regional distribution of risk capital by stage in the UK regions 1998-2007

	Early Stage				Expansion				MBOs/MBIs			
	Amounts		%		Amounts		%		Amounts		%	
Region	1998-2002	2003-2007	1998-2002	2003-2007	1998-2002	2003-2007	1998-2002	2003-2007	1998-2002	2003-2007	1998-2002	2003-2007
South East	446	506	22.05%	21.91%	1357	2666	19.09%	25.19%	3492	3753	21.29%	14.70%
London	676	642	33.42%	27.80%	1653	3855	23.25%	36.43%	5202	10831	31.71%	42.42%
South East and London	1122	1148	55.46%	49.72%	3010	6521	42.33%	61.62%	8694	14584	53.00%	57.12%
South West	85	163	4.20%	7.06%	239	345	3.36%	3.26%	568	1330	3.46%	5.21%
East of England	240	339	11.86%	14.68%	414	390	5.82%	3.69%	1033	1479	6.30%	5.79%
West Midlands	72	34	3.56%	1.47%	482	454	6.78%	4.29%	1764	1271	10.75%	4.98%
East Midlands	51	171	2.52%	7.41%	483	1126	6.79%	10.64%	1312	1760	8.00%	6.89%
Yorkshire	71	163	3.51%	7.06%	230	544	3.23%	5.14%	662	1642	4.04%	6.43%
North West	135	128	6.67%	5.54%	1330	375	18.71%	3.54%	1162	1957	7.08%	7.67%
North East	18	21	0.89%	0.91%	117	183	1.65%	1.73%	239	384	1.46%	1.50%
Scotland	164	70	8.11%	3.03%	644	336	9.06%	3.17%	648	560	3.95%	2.19%
Wales	27	47	1.33%	2.04%	111	260	1.56%	2.46%	254	482	1.55%	1.89%
Northern Ireland	38	25	1.88%	1.08%	50	49	0.70%	0.46%	68	81	0.41%	0.32%
Total	2023	2309	100%	100%	7110	10583	100%	100%	16404	25530	100%	100%

Source: BVCA Investments Activity Reports, various years

Table 11 reveals some interesting trends: first, early stage investments have increased by £286m (12 percent) between 1998-2002 and 2003-2007. London and the South East experienced a marginal increase of £26m (from £1122m to £1148m), while East of England and East Midlands saw a significant increase in the amounts invested in their early stage companies (from £240m to £339m and from £51m to £171m respectively). The changes in the amounts invested in each region are reflected in their share of venture capital investments. London and South East lost approximately 6 percent and Scotland percent of their share in the early stage market, while East Midlands,

Yorkshire, East of England, and the South West gained 5 percent, 3.5 percent, 3 percent and 2.8 percent respectively.

Second, expansion stage investments have increased by £3,473m (33 percent) between the period 1998-2002 and 2003-2007 from £7110m to £10583m respectively. This increase is mainly evident in London and the South East - two regions that saw a jump in their share of this segment of the market by 19.3 percent. East Midlands and Yorkshire experienced a much more moderate increase of 3.8 percent and 1.9 percent respectively. The North West on the other hand, lost 15.2 percent of its share in the expansion market, followed by Scotland with 5.9 percent, West Midlands and East of England with 2.5 percent and 2.1 percent decrease respectively.

Finally, MBOs/MBIs (Management Buyout's/Management Buyin's) investments saw an increase of £9,126m (36 percent) during the same reporting periods, from £16404m to £25530m. London and the South East saw an increase of 4.1 percent followed by Yorkshire with 2.4 percent. West Midlands and Scotland lost 5.9 percent and 1.8 percent of their share in the MBOs/MBIs market respectively and all remaining regions either experienced small losses or remained static.

While some regions such as London and the South East performed remarkably well in expansion and MBOs/MBIs, Scotland and the West Midlands seem to have lost significant values of investments in all segments of investments and this is reflected in the reduced size of the investments share they currently possess. This development shows that while private equity in the 1980s and 1990s helped close the risk capital distribution gap between the UK regions – as observed by Mason and Harrison – private equity has now been responsible for widening the regional distribution gap between the UK regions. In addition, it is clear that early stage investment was the only segment of the market in which the investments gap amongst the UK regions has been narrowed, while it has been widened in expansion and MBOs/MBIs investments. The question on what may have led to the narrowing of the early stage disparity gap will be investigated later in this chapter.

5.3 Regions' expected share of the VC market

The question that now arises is whether this distribution of investments to the regions is "fair". For example, is it fair for Wales to receive around 2 percent of all VC amounts invested (see Table 10). Should Wales expect to have more or less? In order to answer these questions there is a need to identify a measurement of fairness or what might be regarded as an expected level of investment activity.

BVCA statistics on investment activity are disaggregated by region and by stage, and have been used in previous studies to examine the uneven geography of venture capital investments. There are various ways in which to measure the regional distribution of venture capital investments. Essentially there are three critical decisions. First, are venture capital investments measured in terms of number of investments or amount invested? Second, what types of venture capital investments are included? Investment statistics are disaggregated by stage of investment (start-up, other early, expansion and MBO/MBI). Third, should venture capital investment in each region be compared with that region's stock of companies, new firms or employment? Different conclusions may arise depending on the choices made. The following table presents the regional distribution of venture capital in the form of *location quotients* which indicate each region's share of private equity investments as a ratio of that region's share of national business activity (measured by the number of VAT-registered companies, which is one proxy for what might be regarded as the average expected level of investments activity). A value of over one indicates that a region has more than its expected share of venture capital investments based on that region's share of the national business population whereas a value of less than one indicates that its share is less than expected.

Table 12: Location quotient 1992-1998 and 1999-2007

Region	1992-1998	1999-2007
South East	n.a.	1.19
London	n.a.	2.12
South East and London	1.21	1.67
South West	0.65	0.48
East of England	0.78	0.60
West Midlands	1.21	0.77
East Midlands	1.25	1.12
Yorkshire	0.83	0.72
North West	1.21	0.79
North East	0.74	0.56
Scotland	0.88	0.60
Wales	0.36	0.47
Northern Ireland	0.26	0.19

Source: Mason and Harrison 2002 , ONS 2008 and BVCA various reports

Table 12 illustrates that London and South East have significantly more private equity investments than "expected" (1.67 location quotient). Mason and Harrison (2002a) had calculated London and South East location quotient as 1.21 for the period 1992-1998. In fact, during the last decade, only London and Wales experienced an increase in their location quotient and all the remaining regions

saw even fewer investments in relation to their "fair" or "expected" share than the decade before. Table 13 examines the expected share of investments by stage.

Table 13: Regional distribution of venture capital and private equity 1998-2007

Region	Number of active business	%	Early stage investments (£000)	%	Location quotient	Early stage & Expansion Investments (£000)	%	Location quotient	MBOs/MBIs	%	Location quotient	Total investments (£000)	%	Location quotient
South East	369,240	16.05%	952	21.98%	1.37	4975	22.59%	1.41	7245	17.28%	1.08	12220	19.11%	1.19
London	388,600	16.89%	1318	30.42%	1.80	6826	30.99%	1.84	16033	38.23%	2.26	22859	35.74%	2.12
South East and London	757,840	32.93%	2270	52.40%	1.59	11801	53.58%	1.63	23278	55.51%	1.69	35079	54.85%	1.67
South West	205,635	8.94%	248	5.72%	0.64	832	3.78%	0.42	1898	4.53%	0.51	2730	4.27%	0.48
East of England	233,400	10.14%	579	13.37%	1.32	1383	6.28%	0.62	2512	5.99%	0.59	3895	6.09%	0.60
West Midlands	191,390	8.32%	106	2.45%	0.29	1042	4.73%	0.57	3035	7.24%	0.87	4077	6.37%	0.77
East Midlands	157,270	6.83%	222	5.12%	0.75	1831	8.31%	1.22	3072	7.33%	1.07	4903	7.67%	1.12
Yorkshire	166,400	7.23%	234	5.40%	0.75	1008	4.58%	0.63	2304	5.49%	0.76	3312	5.18%	0.72
North West	232,935	10.12%	263	6.07%	0.60	1968	8.94%	0.88	3119	7.44%	0.73	5087	7.95%	0.79
North East	62,310	2.71%	39	0.90%	0.33	339	1.54%	0.57	623	1.49%	0.55	962	1.50%	0.56
Scotland	145,395	6.32%	234	5.40%	0.85	1214	5.51%	0.87	1208	2.88%	0.46	2422	3.79%	0.60
Wales	90,985	3.95%	74	1.71%	0.43	445	2.02%	0.51	736	1.76%	0.44	1181	1.85%	0.47
Northern Ireland	57,665	2.51%	63	1.45%	0.58	162	0.74%	0.29	149	0.36%	0.14	311	0.49%	0.19
Total	2,301,225	100.00%	4332	100.00%		22025	100.00%		41934	100.00%		63959	100.00%	

^Number of active businesses in 2007

By disaggregating the data into stages of investments it is revealed that London has significantly more early stage, early stage and expansion and MBOs/MBIs investments than expected (1,80, 1,84 and 2,26 respectively). However, when taking into account that early stage investments and expansion and early stage investments count for only 7 percent and 34 percent of all investments respectively while MBOs & MBIs count for 66 percent, it becomes obvious that the unequal distribution of risk capital is due to the high concentrations of MBOs and MBIs investments.

Early stage investments are over concentrated in three regions, London, South East and East of England (location quotients of 1.80, 1.37 and 1.32 respectively) followed by Scotland (0.85), East Midlands and Yorkshire (0.75). West Midlands (0.29), North East (0.33), Wales (0.43) and Northern Ireland (0.58) all had far less share than expected.

5.3.1 Regions' expected share of early stage VC investment in time

Since this thesis is more concerned with venture capital rather than the private equity as a whole, the following table focuses on the *early stage* (i.e. start-up and other early stage) venture capital investments and investigates the expected share of the UK regions since 1998 (both by number of investments and amount). The analysis is presented for four separate time-periods which conform to aggregate investment trends. This also has the advantage of smoothing some of the year-on-year fluctuations in investment activity that are apparent at the regional scale.

Table 14: Distribution of early stage investments in the UK: number and region

region	1998-2000 ('boom years')			2001-3 ('crash years')			2005-7 ('recovery years')			2008 ('financial crisis')		
	No.	%	LQ*	No.	%	LQ	no.	%	LQ	No.	%	LQ
London	252	27.70	**1.86**	217	17.60	**1.14**	289	19.36	**1.15**	78	17.14	**1.08**
South East	190	20.90	**1.36**	233	18.90	**1.20**	282	18.89	**1.18**	74	16.26	**1.03**
South West	36	3.96	0.41	56	4.54	0.48	106	7.10	0.79	25	5.49	0.58
East of England	107	11.76	**1.17**	205	16.63	**1.66**	161	10.78	**1.06**	29	6.37	0.63
West Midlands	39	4.29	0.51	57	4.62	0.56	92	6.10	0.73	45	2.42	0.35
East Midlands	28	3.08	0.45	31	2.51	0.37	60	4.02	0.59	11	9.89	**1.20**
Yorkshire & The Humber	37	4.07	0.55	44	3.57	0.50	49	3.29	0.46	28	6.15	0.86
North West	56	6.15	0.63	117	9.49	1.00	212	14.20	**1.40**	79	17.36	**1.81**
North East	22	2.42	0.95	40	3.24	**1.29**	45	3.01	**1.11**	22	4.84	**1.88**
Scotland	106	11.65	**1.59**	101	8.19	**1.15**	110	7.37	**1.17**	33	2.86	0.67
Wales	15	1.65	0.35	57	4.62	**1.28**	50	3.35	0.85	13	7.25	1.04
N Ireland	22	2.42	0.72	75	6.08	**1.83**	38	2.54	**1.01**	18	3.96	**1.21**
TOTAL	910			1233			1493			455		

Table 15: Distribution of early stage investments in the UK: amount invested and region

region	1998-2000 ('boom years')			2001-3 ('crash years')			2005-7 ('recovery years')			2008 ('financial crisis')		
	£m	%	LQ*	£m	%	LQ	£m	%	LQ	£m	%	LQ
London	329	22.0	**1.43**	229	24.9	**1.56**	524	29.74	**1.76**	172	47.8	**1.13**
South East	522	34.9	**2.10**	238	25.8	**1.64**	353	20.03	**1.25**	64	17.8	**3.02**
South West	67	4.5	0.50	26	3.9	0.42	144	8.17	0.91	12	3.3	0.35
East of England	111	7.4	0.76	216	23.5	**2.32**	228	12.94	**1.28**	20	5.6	0.55
West Midlands	62	4.1	0.50	17	1.8	0.22	28	1.59	0.19	12	3.3	0.41

East Midlands	45	3.0	0.44	22	2.4	0.35	144	8.17	**1.20**	9	2.5	0.36
Yorkshire & The Humber	76	5.1	0.72	10	1.1	0.16	137	7.76	**1.07**	5	1.4	0.19
North West	103	6.9	0.76	54	5.9	0.61	99	5.62	0.56	23	6.4	0.67
North East	15	1.0	0.40	6	0.7	0.26	16	0.91	0.34	10	2.8	**1.08**
Scotland	129	8.6	**1.19**	64	6.9	0.99	49	2.78	0.44	24	6.7	0.13
Wales	14	0.9	0.20	31	3.4	0.78	29	1.65	0.42	2	0.6	0.95
N Ireland	24	1.6	0.48	25	2.7	0.85	11	0.62	0.25	7	1.9	0.60
TOTAL	1497			921			1762			360		

The regional distribution of early stage venture capital investments (Table 14) contrasts sharply with the regional distribution measured in terms of amounts invested (Table 15). For the period 2005-7, regions with more than their expected share of venture capital investments *by number* included both the core regions of London, the South East and East of England and also several peripheral regions (the North East, the North West and Scotland). Regions with fewer than expected investments included Yorkshire, the East Midlands, the West Midlands, the South West, Wales and Northern Ireland. It is worth noting that all regions with the exception of London and the South East, have either increased their share of investment or remain relatively stable between the period 1998-2000 and 2005-2007, indicating a narrowing of regional disparities. In 2008, when the onset of the financial crisis resulted in a downturn in venture capital activity, London and the South East continued to have more than their expected share of venture capital investments, along with the North West, the North East, Scotland and also the West Midlands and Northern Ireland (Table 14).

However, a rather different picture emerges when the *amount invested* is considered. For both the 2005-7 and 2008 periods London and the South East both had more than their expected shares of early stage venture capital. The East of England, East Midlands and Yorkshire also had more than their expected shares of investment activity in the 2005-7 period, but in the latter two regions (which both had lower than expected shares of early stage venture capital investments by number) this is an outcome of one atypical year and in the other years their location quotients were less than one. In 2008 the regional distribution of early stage venture capital by amount was dominated by London which attracted almost half of the total. Only London and the South East, along with the North East, attracted more than their expected shares of early stage venture capital by amount (Table 15).

Several regions therefore have significantly less than expected shares of venture capital investment by value but a greater number of venture capital investments than expected. This group comprises the North East (2005-7 only), North West, Northern Ireland, Scotland and the West Midlands (2008 only). The greater than expected volume of venture capital investments in these regions clearly reflects their large numbers of small scale investments, a point returned to later when considering the nature of these deals.

The geographical distribution of venture capital investment over time has not been stable. Comparing the boom period of the late 1990s, the post 2000 downturn, the mid-decade recovery and the onset of the financial crisis (2008) reveals some contrasting trends for different regions.

London and the South East have both consistently attracted more than their expected shares of early stage venture capital (both number and amount) across all four periods. However, whereas London's share of early stage venture capital in terms of amount invested has steadily increased over the past 10 years, from 22 percent in the boom years to 48 percent in 2008 (Table 15), the South East's share of both the number of investments and amount invested has fallen over the same period. The East of England attracted more than its expected investment in the crash (2001-3) and recovery (2005-7) periods. Scotland's position has deteriorated over the four periods in terms of its share of venture capital investment by value, having more than its expected investment in the boom of the late 1990s but less than its expected share in subsequent periods. However, it has consistently had more than its expected share of investments by number, reflecting the active role of Scottish Enterprise in the venture capital market and, in particular, the launch of its very successful co-investment scheme in 2003 (Hayton et al. 2008). The North East and the North West have significantly improved their positions since 2001 in terms of having had more than their expected shares of venture capital investments, but only in terms of numbers of investments.

From the above analysis it becomes obvious that in the current decade we experience a more "even" distribution of early stage investments (in terms of number of deals) in the UK regions compared with the previous decade. Table 15 also suggests that London based companies receive significantly larger deals compared with the rest of the regions. In order to investigate the reasons behind this development, it is necessary to analyse each regions' investments landscape. Who are the main sources of venture capital investment in the UK regions? How they have changed since the late 90s? Who is responsible for the more "even" distribution of early stage investments (in terms of number of deals) in the UK regions compared with the previous decade? What has been the effect of the changes in the sources of venture capital on the geography of venture capital investments? The

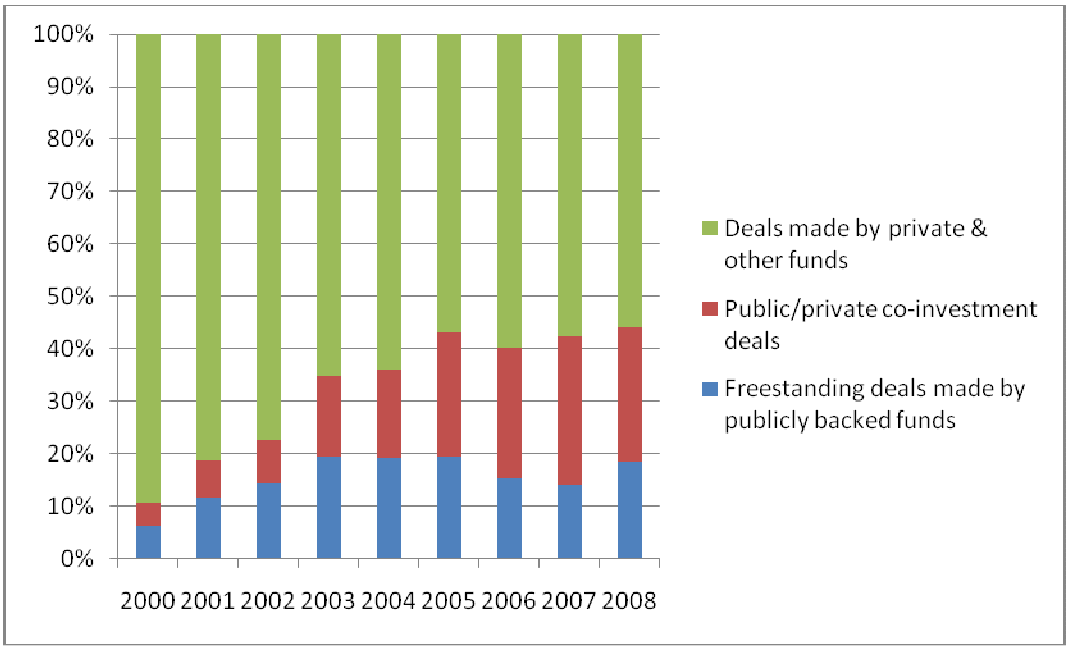
following part of this chapter seeks to address these questions by analysing the regional investment characteristics of each region.

5.4 Source of investments

Concerns about the diminishing volume of early stage venture capital investment have been a recurring theme throughout the post-war era (Mason and Harrison 1991a). As mentioned in chapter 3, the favoured approach since the Labour Government came into office in 1997, has been hybrid funds involving a combination of public and private investment, with incentives which enhance the returns or lower the risk to attract private sector institutions to invest, and are managed by private sector fund managers (Murray 2007). Examples include the Early Growth Funds, University Challenge Funds; Regional Venture Capital Funds, and Enterprise Capital Funds *inter alia* (see Appendix I). Many of these funds are regionally focussed. Both the English Regional Development Agencies and the development agencies in Scotland and Wales have also created their own funds, using ERDF or other public sources. A more recent development has been the creation of publicly-funded co-investment funds which invest alongside private investors in the same deals (i.e. the Scottish Co-investment fund). These funds are intended to enhance their liquidity of private sector investors so that they can make new investments which in many cases they would not otherwise make.

Figure 17 reveals that deals involving public sector funds, either investing on their own or co-investing with private investors (funds or individuals), have more than trebled between 2001 and 2007, although both fell by 18 percent in 2008. This represents an increase in their share of investments from 19 percent in 2001 to 44 percent in 2008. Meanwhile, free-standing private sector investments – although increasing in numerical terms from 2002 until 2006 – have declined as a proportion of total investment activity from 81 percent in 2001 to 56 percent in 2008. These trends – two sides of the same coin - underline the growth and current scale of the public sector's involvement in one form or another in the supply of venture capital.

Figure 17: Proportion of investments by type of investor, 2000-2008

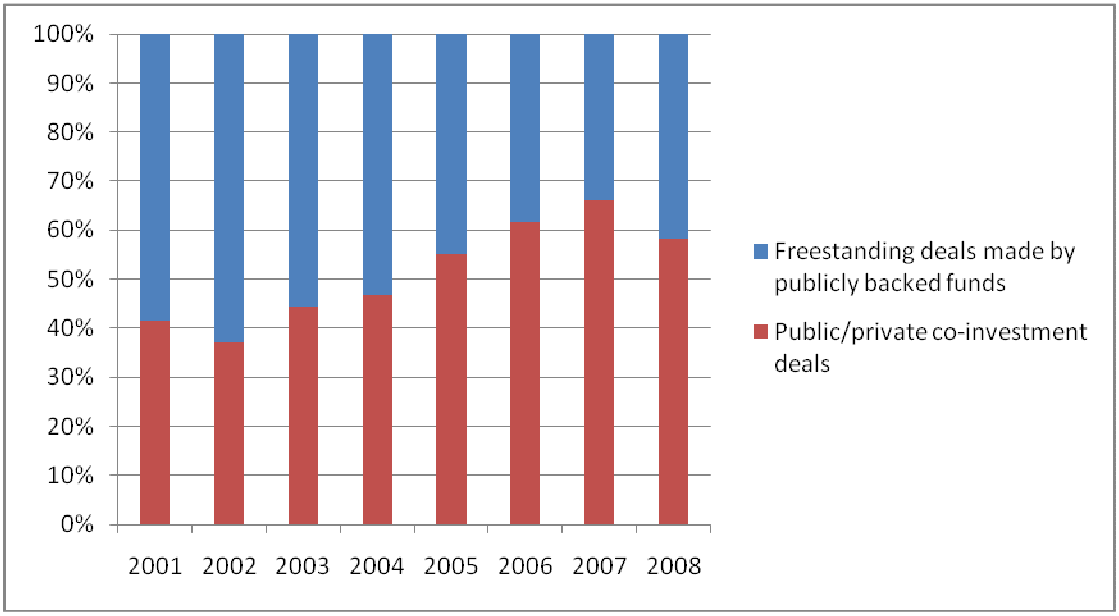


Source: calculated using data from Library House database

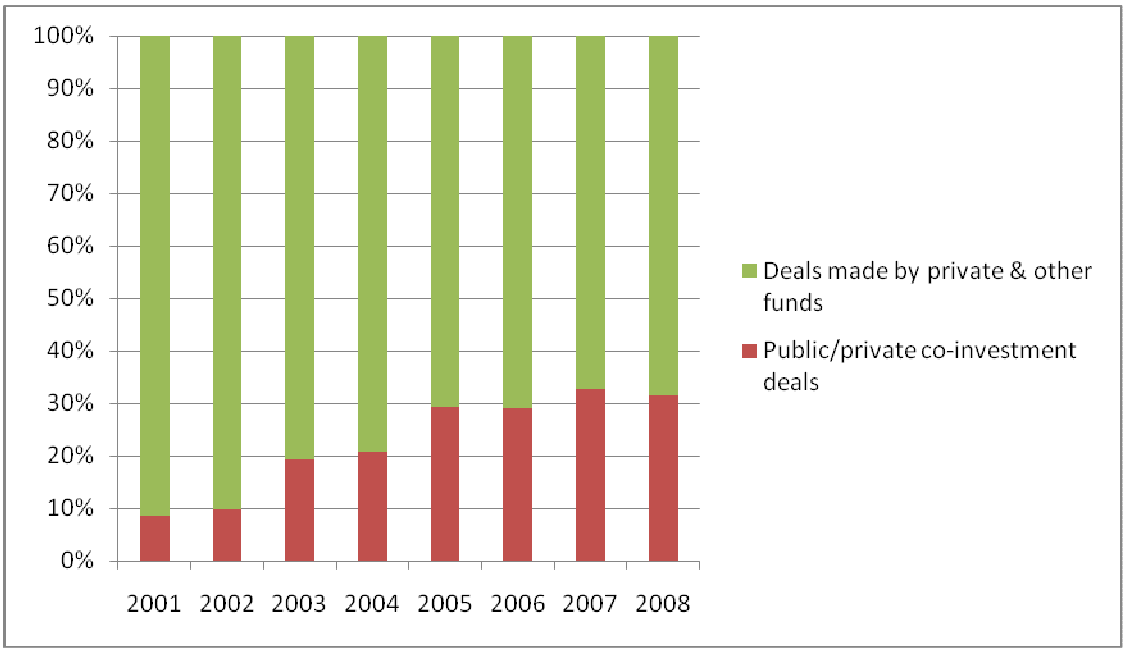
The increasing significance of the public sector has risen on account of its growing use of co-investment as an investment model. Co-investments accounted for 26 percent investments in 2008 compared with just 7 percent of all investments in 2001 (Figure 17). Indeed, public-private co-investments are now the dominant form of public sector venture capital investment, reaching a peak of 67 percent of all deals involving the public sector in 2007 compared with 37 percent in 2001, and since 2005 have exceeded the annual number of free-standing investments by public-sector funds (Figure 18a). One-third of private sector investments were co-investments with public sector funds in 2008 compared with just 8 percent in 2001 (Figure 18b), underlining that a significant proportion of private venture capital investment activity is now supported by the public sector.

Figure 18: Co-investments as a proportion of deals

(a) Public private co-investments deals as a proportion of all deals involving public sector

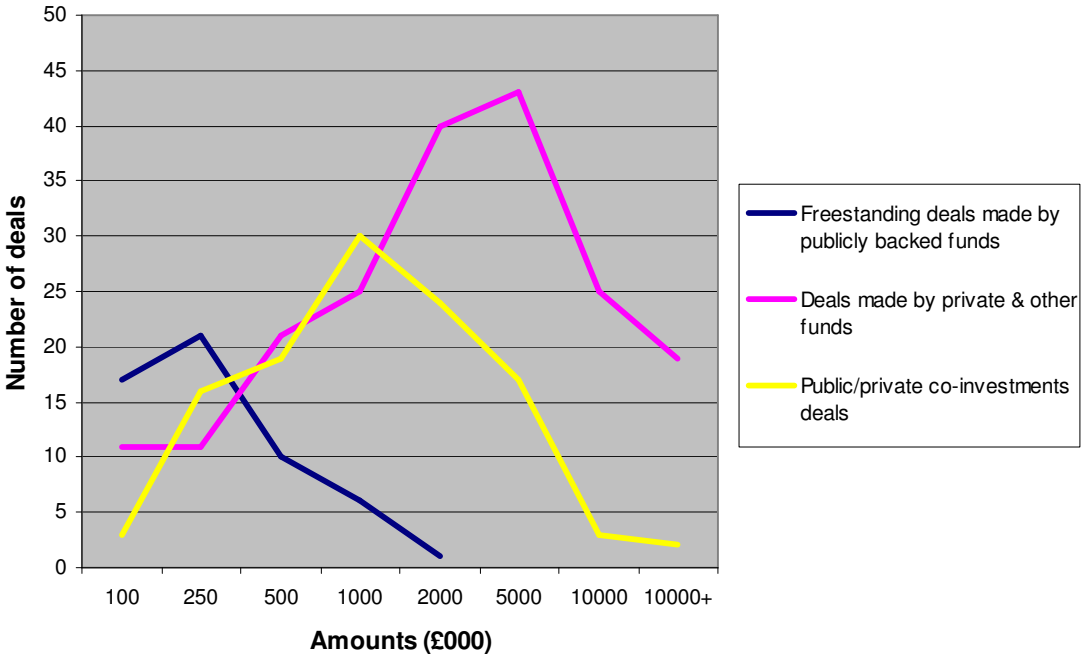


(b) Public private co-investments deals as a proportion of all deals involving private sector



Source: calculated using data from Library House database

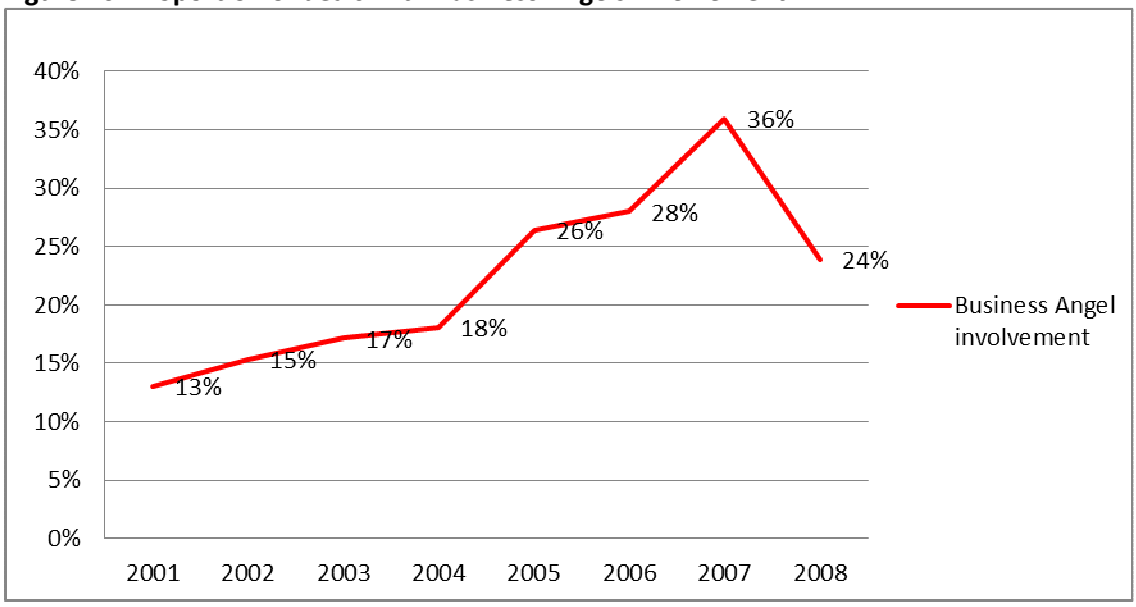
Figure 19: Distribution of deals sizes by type of investor, 2007



Source: calculated using data from Library House database

These trends can be unpacked in two further respects. First, the various types of investors occupy different parts of the funding spectrum (Figure 19). Private investors (funds and individuals) had an average size of £3.7m in 2007 but a very wide size distribution, with 11 percent of deals below £250,000 but 45 percent above £5m. The average public-private co-investment is smaller at £1.5m, with 81 percent of investments at £2m and below. Deals involving only public sector funds were largely confined to £500,000 and under (83 percent) (£378,000 average size). Second, Business Angels have become more significant in both absolute and relative terms. Their investments increased more than threefold between 2001 and 2007, but then dropped back in 2008, while their share investment rose from 13 percent to over 36 percent (Figure 20).

Figure 20: Proportion of deals with Business Angels involvement

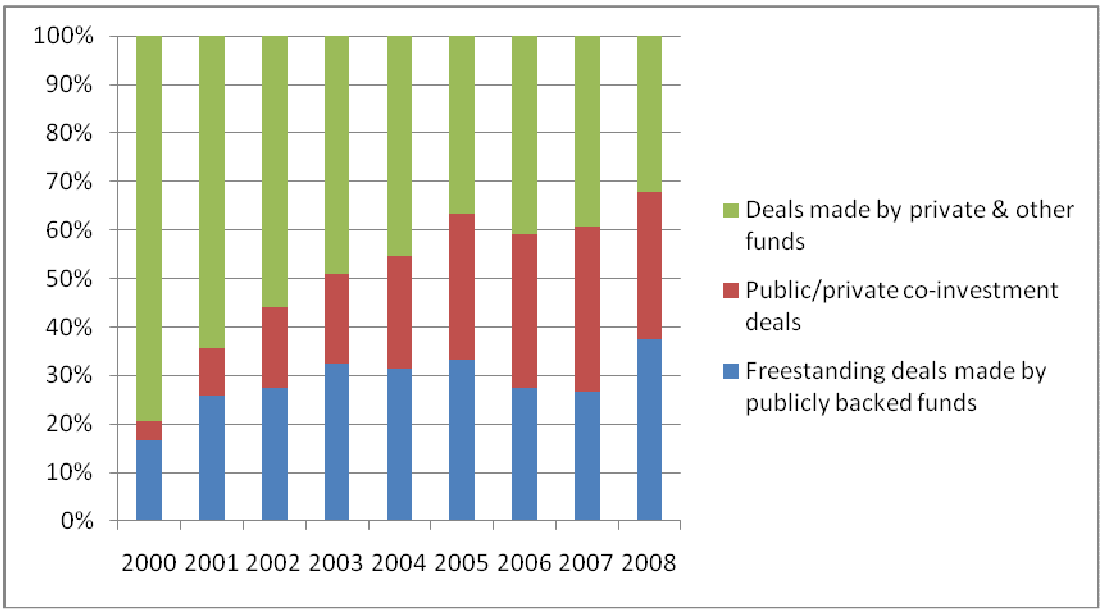


Source: calculated using data from Library House database

5.4.1 Types of investor - early stage investments

The increased involvement of the public sector is even more apparent in the early stage venture capital market. The involvement of the public sector in the supply of early stage venture capital has increased significantly to a situation in which it accounts for the majority of such investments (Figure 21). In 2001 public sector funds were involved in 36 percent of investments. By 2003, as the various funds established by the Labour Government came on stream, this had risen to 51 percent and by 2008 accounted for 68 percent of all investments. This reflects the growth of co-investment schemes which have risen from 10 percent of all investments in 2001 to more than 30 percent since 2005. The proportion of public sector investments which are co-investment deals has risen from 28 percent in 2001 to peak at 56 percent in 2007, falling back to 45 percent in 2008. Nevertheless private sector investors remain important, both as free-standing investors and co-investment partners, involved in more than 60 percent of all investments annually between 2001 and 2008 and in some years this proportion was in excess of 70 percent. But what has happened, of course, is that an increasing proportion of early stage private sector investments have been co-investments with public sector funds, rising from 13 percent in 2001 to more than 45 percent since 2005, while the proportion of independent private sector investments has fallen, accounting for just 32 percent of all investments in 2008.

Figure 21*:* Early stage investments by year and type of investor 2000-2008



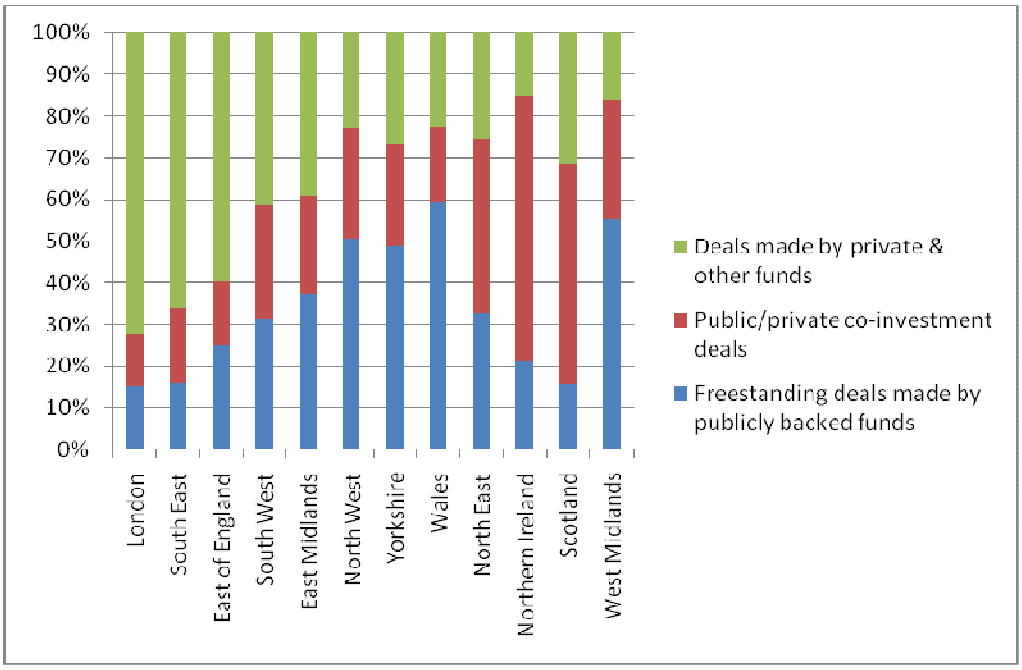
Source: calculated using data from Library House database

Year-on-year trends in early stage venture capital investment since the post-2000 dotcom crisis have been volatile. Amounts invested have not recovered to their 2000 peak although the number of investments have risen, reflecting an increase in investments of under £500,000. The public sector has become proportionately more significant as an investor, largely on account of the growth of public-private co-investment which is now the dominant way in which the public invests in early stage companies (Figure 21). Private sector investors remain prominent in terms of the number of investments they make, but according to the empirical results, are now much more likely to investment alongside the public sector in co-investment deals. This could be driven by the fact that several publicly backed funds can only invest alongside private funds due to state aid constraints. Alternatively, private funds may want to share the costs of due diligence with public funds. Another explanation could be that since there are not many private funds operating in the early stage market, private funds do not have many options but to co-invest with public funds. The composition of early stage private sector investors has also changed, with an increase in the significance of investments by private individuals, including 'mega angels' investing alone, angel syndicates and other forms of organised angel investing, and a decline in the significance of private sector venture capital funds –publicly backed funds on average invest smaller amounts than private funds, making them attractive partners to individual investors that operate in the seed and early stage market.

5.5 The regional distribution of venture capital investments: types of investors

Using Library House data it was possible to decompose the types of venture capital investors in each region (Figure 22).

Figure 22: Proportion of different types of investors in early stage deals in the UK regions 2000-2008

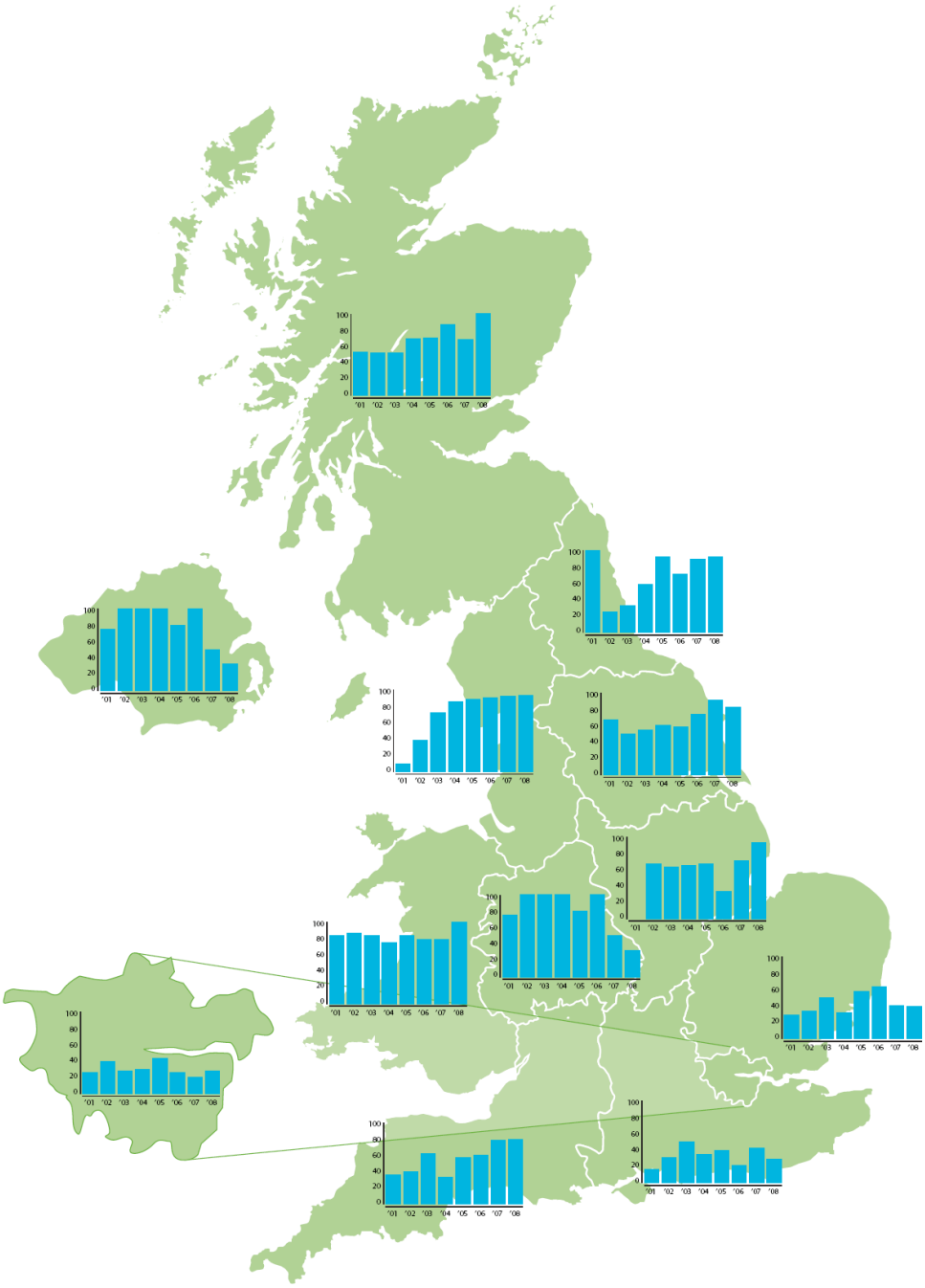


Source: calculated using data from Library House database

Looking at the entire 2000-2008 period, and only considering early stage investments, there is a clear distinction between, on the one hand, London, the South East and East of England and, on the other hand, the rest of the country in terms of the proportion of deals involving private and public sector investors. Looking at the period as a whole, deals exclusively involving private investors accounted for more than 70 percent of all investments in London, nearly two-thirds in the South East and 60 percent in the East of England. In the South West and East Midlands the proportion of free-standing private sector investments was around 40 percent, dropping to 32 percent in Scotland, around 25 percent in Yorkshire, the North West, North East and Wales, and around 15 percent in West Midlands and Northern Ireland. This means that in regions North and West of the Humber-Severn axis, the public sector is involved in upwards of three-quarters of early stage venture capital investments. Moreover, the proportion of deals involving the public sector has risen over time, reaching over 90 percent in several regions in 2008 (Figure 23). However, the form of public sector intervention varies. In Northern Ireland, Scotland and the North East co-investments between the

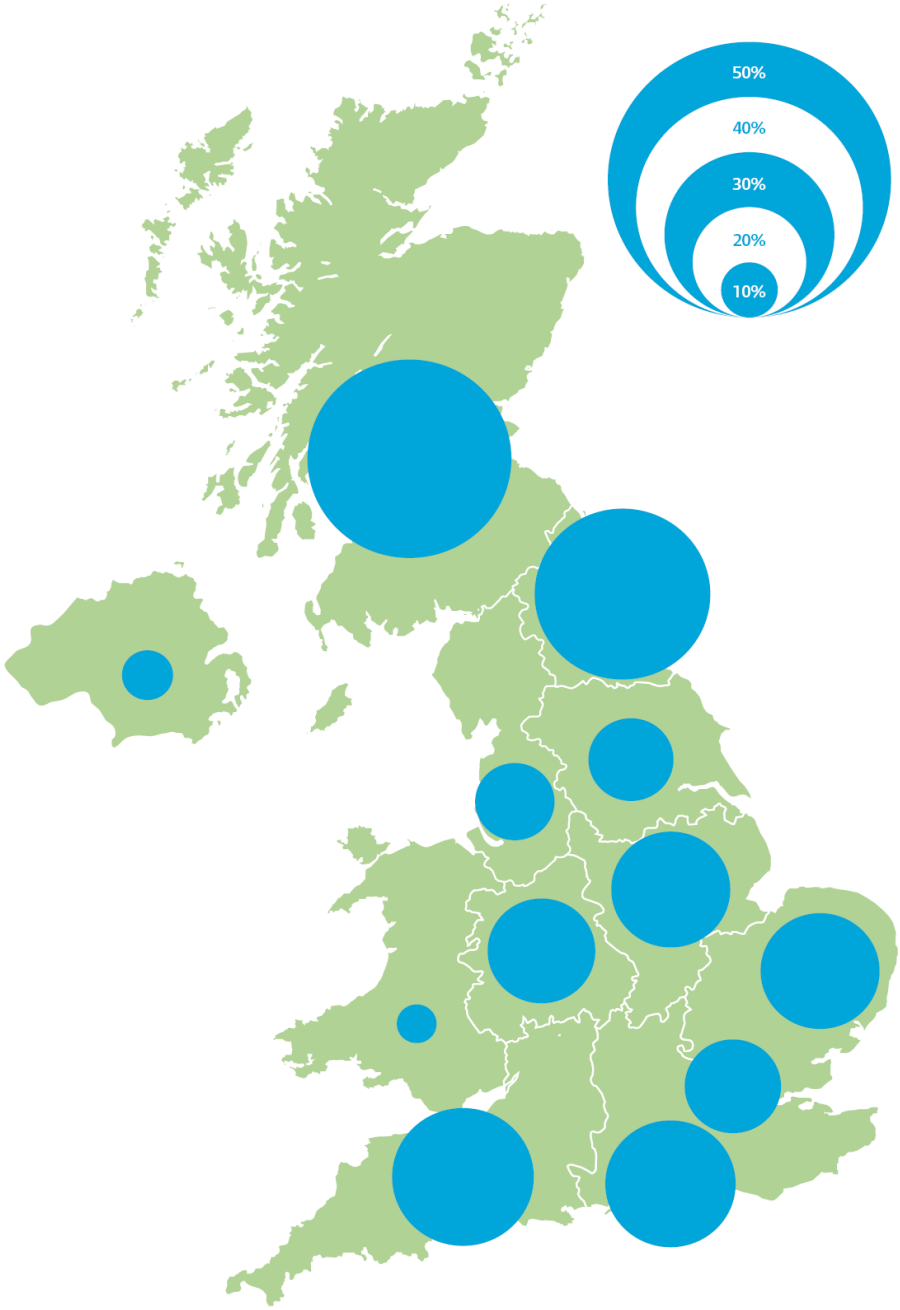
public and private sector dominate, accounting for 64 percent, 52 percent and 42 percent respectively of all investments, whereas in the other regions with high proportions of public sector involvement – notably the West Midlands, Wales, Yorkshire and the North West – free-standing public sector investments account for 50 percent or more of all investments.

Figure 23: Proportion of investments involving the public sector by year by region



Source: calculated using data from Library House database

Figure 24: Proportion of early stage deals involving Business Angels by region



Source: calculated using data from Library House database

The Library House data also provides some insight into regional variations in the relative significance Business Angels. However, as noted earlier, the data is partial, with Business Angels only identified in deals where they have invested alongside venture capital funds. With this important caveat, Business Angels are most prominent in Scotland, accounting for over one-third of early stage investments and the North East where they account for 30 percent. They are least significant in Yorkshire and The Humber, North West, Northern Ireland and Wales (Figure 24). One way in which to interpret this regional pattern is in terms of the dominant form of public sector intervention (fund

or co-investment), discussed in the previous paragraph. There is an association, at least in those regions that are at the extremes of the distribution, between the relative importance of co-investments by the public sector and the relative importance of Business Angels. It might be that Business Angels are crowded out in regions where the public sector invests on its own whereas their numbers are boosted in regions with co-investment funds. But based on the Scottish experience it may be that a well-developed angel market is actually a pre-requisite for the successful operation of co-investment funds. The Scottish experience also suggests that the successful operation of a co-investment fund provides a further boost to the development of new angel groups (Hayton et al. 2008).

5.6 A historic overview of the venture capital activity in Wales

Over the last 25 years, Wales, mainly through the, now abolished, Welsh Development Agency has attempted to stimulate innovation by working through the supply chain feeding into large inward investors as the stimulus for local companies to increase their innovation activity. Indigenous supply chain firms were pressed by their parent companies and the WDA to be more innovative and they succeeded to the extent that Wales was considered as "darling" (Cooke 2003) of the Regional Policy Directorate of the European Union and together with 5 other European Regions Wales was first to introduce the Regional Technology Plan in 1994. Despite a relatively large share of inward investment, the manufacturing sector remains a small and declining source of employment. In fact, inward investment created over the past decade created very few jobs (Lovering 1999).

A number of innovation studies involving Wales have been conducted since 1996 (when the first RTP ended) i.e. Innovation Networks and Regional Policy in Europe Landabaso et al. 1999, On-going evaluation of the RIS projects, ECOTEC 1999, Assessment of the regional innovation and technology strategies and infrastructure (RITTS) scheme, Charles et al. 2000). The common claim is that RTP/RITTS and RIS have positive organisational inputs building consensus amongst regional Welsh actors. However, questions have been raised as to its impact on long-term structural changes in Wales and its transformative capacity in relation to what Cooke calls "Institutional Regional Innovation Systems (IRIS)" (Cooke 2003).

5.6.1 Venture capital activity in Wales

The report *"Finance Wales: A reflection on the first 5 years"* (CMI 2007)provides a valuable source of information for the long history of publicly backed venture capital investments in Wales, from the

inception of WDA in 1975 to the establishment of Finance Wales in 2001 and onwards. The report argues that from its inception in 1975, the WDA made various attempts at creating a favourable environment for investments in Wales. These began with a policy at investing in Welsh quoted companies, attracting foreign direct investments and more recently, by setting up venture capital investments initiatives.

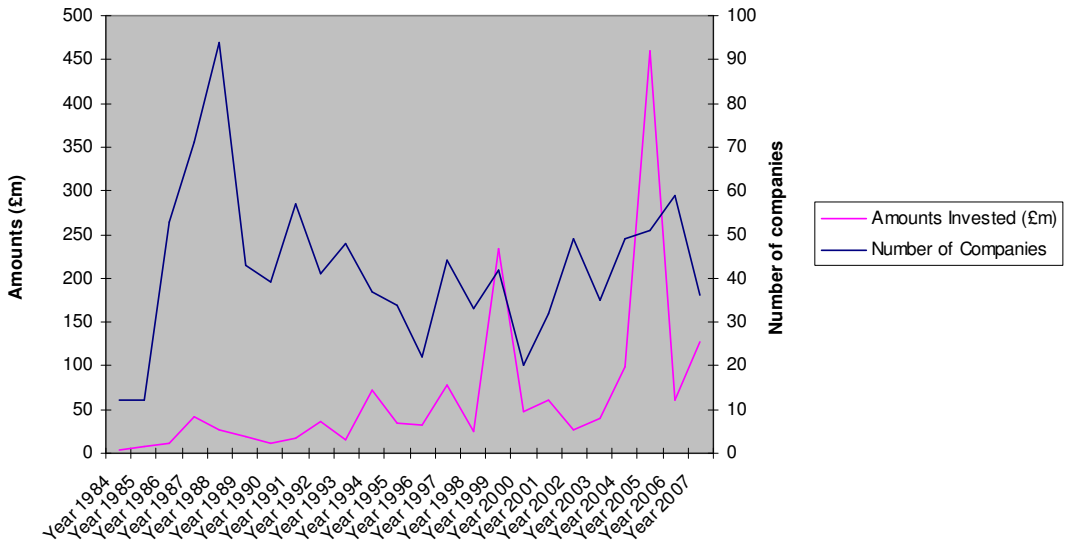
The first such effort was the establishment of the Wales Venture Capital Fund (WVCF) with a modest £5m budget and with no significant success. WVCF was followed by the Welsh Enterprise Fund which had similar performance as its predecessor and came to its natural end in the late 90s. In mid 90s the Wales Fund Managers were also established. Between 1996 and 2000, the WDA's Finance Programmes Department developed and launched a Business Angels network, a University Spin out programme, support for firms seeking access to capital and a senior business mentor programme. During this period, three supply side activities were also launched – the Wales Innovation Fund (WIFL); the Wales Small Loan Fund (WSLF) and a University focussed interest free loan scheme delivered as part of the Wales Spin out programme (CMI 2007). The decision of the European Commission to allow regions to use ERDF money to support regional investments funds and the successful example of the use of such money by English and Scottish based regional development funds, whetted the appetite of the Welsh regional stakeholders for the creation of a similar organisation in Wales. In this context, in 1999 the argument was won for the creation of a similar initiative in Wales in order to take advantage of the European Funding opportunity in 2000 to 2006. Thus, Finance Wales was established in 2001. On formation, Finance Wales inherited from the WDA a suite of equity and loan funds and obtained large tranches of European funding from the Objective 1 & 2 Programme combined with private sector finance from Barclays Bank. These public/private sector funds made more than £80m available for investments in Welsh SMEs (CMI 2007).

Since the inception of Finance Wales in 2001, the majority of venture capital investments that took place in Wales involved one or more publicly backed investors (Library House). As shown earlier, the importance of publicly backed investors especially at the early stage companies has been increased in all UK regions. All these developments significantly increase the role of publicly backed funds in Wales and placed pressure one the government to enhance its policies in the context of creating a self sustaining financial community in Wales.

Between 1984 and 2007, £1.6 billion of risk capital have been invested in over one thousand companies based in Wales, with £1.2 billion of which, invested in the last decade (BVCA). While

formal venture capital in Wales represents only 0.13 percent of the welsh GDP[1], it compares favourably with the UK average of 0.05 percent and it is similar to the US average (0.14 percent).[2]

Figure 25: Investment Activity in Wales since 1984



Source: Table created using BVCA data

Figure 25 illustrates the increasing trend in venture capital investments in Wales since 1984. In 1999 and in 2004 two large MBO are clearly apparent in the graph. However, there is an upward trend on the number of companies receiving VC investments since the late 1990s.

[1] Based on 2006 figures, GDP for Wales was £47b (Wikipedia)
[2] See NESTA (2011), Atlantic Drift, NESTA

Figure 26: Venture capital Investments and regional gross added value in 2007

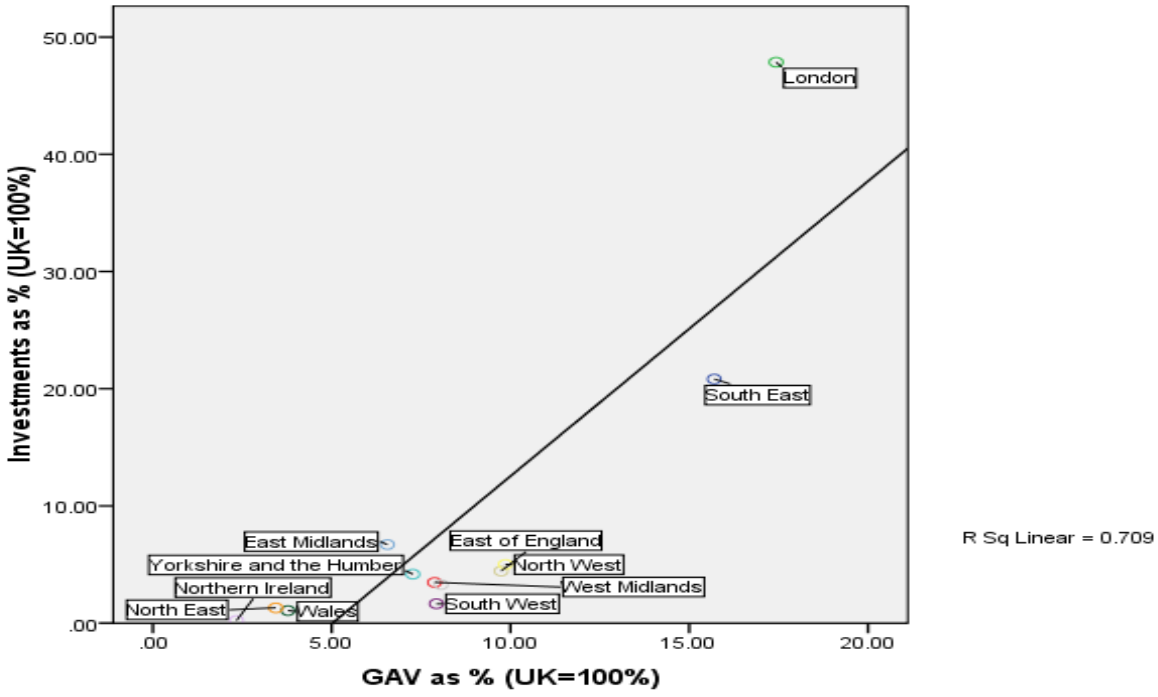


Figure 26 illustrates the relationship between Gross Added Value (GAV) per capita as a percentage of the total UK, and the venture capital investments for all UK regions. Wales together with the North East and Northern Ireland belong to a group of regions which have relatively low GAV and VC investments activity.

There are only few VC players that are currently operating in Wales with the largest of them being Finance Wales. There are only three venture capital Funds that are currently based in Wales, Finance Wales and Welsh Fund Managers and the University Challenge Fund (UCFs) run by Cardiff University. The Welsh Assembly government has also been active in VC market by investing independently. Another investment scheme operating in Wales is Biofusion which explores IP opportunities coming out from Cardiff University. Several other VC funds that are not located in Wales have been investing in Welsh based companies during the last decade.

Table 16: Main investors in Wales

VC firm	*No of investments*	*Share of market*
Finance Wales	46	39%
Wales Fund Managers	12	10%
HSBC	7	6%
Cardiff UCF	5	4%
Advent	4	3%
Welsh Assembly	4	3%
3i	3	3%
Scottish Equity Partners	3	3%
NWD Invest	3	3%

Source: Thomson Reuters

The sample dataset that was used in previous analysis (see chapter 5) contains 119 venture capital investments that were made to Wales based companies. Sixty percent of these investments were made by one or more publicly backed funds. The domination of Finance Wales which is a publicly backed VC fund, is clearly evident in Table 16. Finance Wales has been involved in 46 of those deals which is equivalent to 39 percent of all deals and 61 percent of publicly backed deals. Wales is currently receiving an expected share of VC investments (location equation 0.95) performing better than regions such as West Midlands, East Midlands, Yorkshire and the Humber, South West. In the absence of FW the location equation would have been much lower.

5.7 Conclusion

On a national scale, the supply of early stage venture capital recovered during the mid 2000s after its collapse in the wake of the dotcom crisis in 2001 but fell back in 2008 with the onset of the financial crisis. During this period the provision of early stage venture capital has changed, with public sector venture capital funds becoming more important, largely as a result of the growth of co-investment schemes which invest alongside Business Angels and private sector funds. Both public sector funds investing on their own and private investors investing on their own have declined in both relative and absolute significance since 2004-2005. The composition of private sector investors has also changed, with funds declining in significance and various types of Business Angels (high net worth individuals and angel groups) becoming more important.

On a regional scale, the disparity gap between regions has been narrowed and several regions have

more than their expected shares of early stage venture capital investments, measured by number of deals, mainly due to the increase in publicly backed investments. At first glance this appears to be a positive development. However, closer inspection reveals potentially problematic features. First, the high level of investment activity is largely a function of the public sector venture capital funds, either investing on their own or in conjunction with private sector investors. Indeed, over the period as a whole the public sector has been involved in more than three-quarters of the early stage investments made in the midlands and north, rising to more than 90 percent in some regions in 2008. The proportion of free-standing private sector deals in these regions is correspondingly low. Second, the average size of these investments is small, reflecting the small fund sizes and maximum investment thresholds of public sector schemes. Early stage venture capital, measured in terms of the amount invested, continues to be over-concentrated in core regions of southern England as it always has been (Mason 1987; Martin 1989, 1992; Mason and Harrison 1991, 2002a). So, from a regional perspective the UK now appears to have two early stage venture capital markets. In London, the South East and, to a lesser extent, the East of England, private sector investors dominate investment activity, investing for the most part on their own rather than with public sector co-investors. This is in contrast with the remainder of the UK where the early stage venture capital market is under-pinned by extensive public sector involvement. In some regions this takes the form of free-standing investments by public sector funds whereas in other regions it takes the form of co-investments with the private sector. Private investors investing on their own, account for only a minority of investments in these regions and have been more likely to invest alongside the public sector in co-investment deals than entirely independently. Moreover, this gap between London and the South East and the rest of the country has widened since 2001, during periods of both declining and expanding venture capital investment activity.

As a result, the effect of the increased government intervention in the supply of venture capital on the geography of venture capital in the UK has been twofold. First, the public sector has now become an important co-investor partner especially at the early stage investments, leveraging high proportion of private investments. Second, on one hand it has helped narrow the regional disparity gap in early stage investments but, on the other hand, it has resulted in several regional VC markets now becoming dominated by public funds. The key question is whether this matters and why.

The aim of the public sector schemes has been to stimulate the supply of new sources of finance, ensuring that each region has access to regional based VC funds and demonstrating that investors in early stage funds can make robust returns, thereby promoting the private sector venture capital

industry (Mason and Harrison 2003). The question regarding how significant these interventions have been in terms of increasing the supply of early stage finance to SMEs can only be addressed in fairly narrow terms. On one hand, these funds increased the supply of VC finance to regional SMEs by making available to them approximately £1b during the last decade (SQW 2010). This poses the question as to whether or not this increased public sector involvement in early stage venture capital investing has 'crowded out' private sector investors. While, given the limitations of the data, it is not possible to provide a conclusive answer to this question, there is no evidence that this is occurring. First, the increase in public sector investment since 2000 has reduced the average size of investments in the sub-£2 million category; this would suggest that they have filled a gap in the supply of small investments. Second, co-investment schemes would appear to have boosted angel investment activity, and therefore attract more private money into the early stage market.

On the other hand, the financial returns of the publicly backed funds have been negative and below industry average (NAO 2009). In addition, companies that received VC finance from publicly backed funds have not performed significantly better than matched firms which did not receive funding from such sources (NESTA and BVCA 2009). These findings are open to several possible interpretations. From a demand-side perspective they suggest that the UK does not have a large stock of high potential firms that are only being held back by a simple lack of equity funding. This interpretation also allows for the possibility that savvy entrepreneurs positively discriminate in favour of private sector investors when making their choice of financial partner. Alternatively, from a supply side perspective it may reflect the limitations of the public sector venture capital model. First, the focus of such funds on specific geographical areas restricts the supply of suitable investment opportunities, particularly in smaller regions (see NESTA 2009). Second, the investments made by the public sector venture capital funds is typically too small to meet the funding needs of high-growth firms (SQW, 2009), or allow follow up investments (NESTA 2009).

Overall, the empirical results which suggest that the overwhelming majority of early-stage venture capital investments in many UK regions and nations are publicly backed, in itself is not necessarily a cause for concern: if the alternative is sensible investments not being made, public intervention may be justified. However, as the NESTA and BVCA (2009) study suggests, regions which are dominated by public VC investment will also be overwhelmed by VC backed companies that do not perform much better than those that receive no VC investments.

Alternatively, if the problem is not in the demand side, but the funds are not able to effectively assist businesses due to the way they are structured, this becomes more problematic: businesses in

publicly backed dominated regions may not receive any added value by a VC investments; private investors may not be attracted into the region and finally; it may be difficult for General Partners (GPs) that operate public funds to raise new funds from Limited Partners (LPs) due to the poor financial records and their lack of contacts with private investors.

In both cases, regions with high dependency on public VC investments are faced with the prospect of having a large pool of companies that do not behave as typical VC backed companies and therefore these regions do not benefit from a regional VC industry. As mentioned earlier, companies that receive VC create more jobs and are more innovative than non VC companies.

The following chapter examines whether the implications of the potentially problematic domination of publicly backed funds in several regions influence the innovation performance of these regions: if regions are dominated by publicly backed VC funds, what might this mean for the innovation performance of these regions?

6 CHAPTER 6: THE RELATIONSHIP BETWEEN VENTURE CAPITAL AND INNOVATION

6.1 Introduction

Venture capital plays an important role in the financing and nurturing of high tech, high potential companies. A variety of studies have shown that venture-backed firms are responsible for a disproportionate number of patents and new technologies, and bring more radical innovations to the market faster than lower growth businesses that rely on other types of finance (Kortum and Lerner 2000; Hellmann and Puri 2000, 2002; Hall and Lerner 2010). In fact, venture capital has played an important role in the development of some of the most significant scientific inventions and industries of our times and high-growth, venture-backed firms are also more likely to generate new industries (see Bygrave and Timmons 1992; Timmons and Spinelli 2003). The aim of this chapter is twofold: first to investigate the relationship between venture capital and innovation; and second, to analyse the likely impact of different sources of venture capital (public or private) on the innovation potential of companies. This in turn will provide answers to research questions 2 and 3, namely: *Is a higher volume of VC investment positively correlated with a higher volume of patent applications? And are public funds less effective in investing in companies with the potential to innovate than private funds?*

The significant impact of venture capital on innovation has not been unobserved by policy makers. As demonstrated in previous chapters, successive UK governments have introduced different schemes in support of venture capital finance. Recent evaluations of the government VC schemes have highlighted that publicly backed funds have had a negative financial performance and their overall Internal Rate of Return (IRR) was substantial lower than the IRR reported by private funds (NAO 2009). Furthermore, they have had only a marginal impact on business performance (NESTA and BVCA 2009). Despite their limitations however, public interventions have significantly increased the supply of finance for business seeking equity finance, and the public sector has become considerably more important as an investor in both absolute and relative terms as seen in the previous chapter. This chapter investigates the likely impact of these public interventions on innovation.

This chapter builds on previous U.S. based empirical research which shows that venture capital spurs innovation through the creation of patents and increases in business R&D expenditure, and extends it to the UK level. It investigates the relationship between venture capital and innovation at two

scales, the country and regional scale, using aggregated data for all UK regions on factors that are traditionally considered to indicate innovation activity. The data allows the relations between financing and innovation outputs to be compared across regions and therefore seeks to illuminate the under-researched issue of regional variations in venture capital investments and the role of venture capital in fostering innovation.

An important contribution of this section to the literature is the investigation of the relation between different sources of finance of VC funds and the innovation potential of the companies with which these funds are engaged. This analysis provides preliminary answers to the question: *"do publicly backed funds promote innovation to the same extent that private funds do?"*

6.2 Theories and hypothesis

There are few, if any, dissenters from the view that venture capital plays a central role in the emergence of new industries by funding and supporting innovative companies which later dominate these industries. Indeed, Lerner and Watson (2008) argue that the venture capital model is more effective in commercialising scientific discoveries than the corporate sector, despite the latter's large expenditure on Research and Development (R&D). Venture capital investment speeds the development of companies, enabling them to transform ideas quickly into marketable products and become industry leaders through first mover advantages (Zhang 2007). The process of innovation is a crucial aspect of economic growth, the problem of measuring innovation has not yet been completely resolved (Acs et al. 2001).

6.2.1 Measures of innovation

Patents, number of applications or grants, and business R&D expenditure have been widely used by scholars as proxies of innovation (see Mann and Sager 2007; Hirukawa and Ueda 2011). Both proxies are widely available at industry or country level and partially available at the regional level. Both of these measurements of innovations have important limitations. According to Frenz and Oughton (2005), there are three main weaknesses of patent data. Firstly, patents do not capture innovation by firms that are Schumpeterian imitators, that is, firms that introduce products or processes that are new to their firm but not new to the market or industry. Secondly, not all innovations that are new to the market are patented. Moreover, the propensity to patent may vary significantly across industries and sectors, for example, between manufacturing and services. Thirdly, patents are often registered at the Head Office of an enterprise, thus there are regional distortions that arise as a result of administrative features of the patent system (Smith 2005). In addition, patents are not

always introduced on the market and their economic value can be questionable (Jaffe and Lerner 2004). Griliches summarises these concerns nicely:

"*not all inventions are patentable, not all inventions are patented and the inventions that are patented differ greatly in "quality", in the magnitude of inventive output associated with them*" (Griliches, 1990, p.296).

In addition to these limitations, Verdoni and Galeotti (2009) argue that patent data cannot provide any insight on, what they call, disembodied technological change, such as for example the learning process by which individuals can increase the productivity of the production process thanks to "learning by doing", is clearly left out of a study based on patent data (Verdolini and Galeotti 2009)

Business R&D expenditure although commonly used as a measure of innovation, is an input for innovation rather than an output or product of innovation itself. The scale of innovation depends not only on how much R&D expenditures are spent but also on how efficiently they are spent. As a result R&D expenditures are indirect measures of innovation, whereas patents are a direct measure of innovation (Hirukawa and Ueda 2011). R&D expenditure suffers from measuring only the budgeted resources allocated towards trying to produce innovative activity (Acs et al. 2001). In addition, it is also concentrated in few industries (for example biotechnology and defence industry). According to Frenz and Oughton (2005), for a given industrial structure, the extent to which R&D is a good proxy for (novel) innovation depends on: the amount of 'unsuccessful' R&D expenditure that fails to result in an invention; the extent to which successful inventions are commercialised; and the degree of spillover effects (Frenz and Oughton 2005). Regional R&D figures also suffer from the fact that some R&D is not carried out in the same region as the reporting unit providing the data, thus the figures may be affected by 'head office bias' (Frenz and Oughton 2005).

Conventional measures of innovation activity such as patents and R&D expenditure fail to capture a number of interactive features of research and innovation activity that have been highlighted by the systems of innovation literature. These include: non-pecuniary knowledge acquisition (accidental and deliberate knowledge spill-overs); cooperative agreements between firms; networking between firms and research organizations (Frenz and Oughton 2005).

Keeping in mind the limitations outlined above, and the absence of a more suitable and easily identifiable measurement for innovation for the purpose of this research, the use of patent data with the purpose of investigating the relationship between VC and innovation has several advantages and as Chrilliges puts it:

"after all, patent does represent a minimal quantum of invention that has passed both the scrutiny of the patent office as to its novelty and the test of the investment of effort and resources by the inventor and his organization into the development of this product or idea, indicating thereby the presence of a non-negligible expectation as to its ultimate utility and marketability" (Chrilliches 1998 p.296).

Business R&D expenditure is used as both depended and explanatory variable in the analysis. It is worth noting that patent application is simply a proxy for business innovation and additional proxies for innovation could be used in a future research. In addition, the relationship between the two variables, venture capital investment and patent application, may only show association and not necessarily causation.

The basic theoretical premise of this section is that VC spurs innovation and in particular that VC promotes business innovation by fostering patent creation (Kortum and Lerner 2000; Hellmann and Puri 2001). Building on this premise, three hypotheses have been developed, dealing with the relationship of venture capital with innovation at the regional and at the firm level

Hypothesis 1: Increases in venture capital activity (amounts and deals) will be positively associated with increases in volumes of innovation (patents and business R&D expenditure).

Hypothesis 2: Companies with patents are more likely to secure follow up VC finance compared with companies without patents.

Hypothesis 3: The potential of a firm to innovate (expressed as the ability of a firm to acquire a patent) is associated with the source of VC finance (public or private).

In testing these hypotheses empirically, several controls have been included for the potential confounding effects: stage of investment, industry of operation, size of investment, and year of investment. These controls have been identified in the literature as factors that could potential influence the dependent variables of each analysis and further information on these controls have been outlined in the Research Methodology chapter.

6.3 Relationship between venture capital and innovation, country and regional-level analysis

6.3.1 Country level analysis

This section investigates the relationship between several innovation related indicators with the venture capital activity performance variations in time and in space. Table 17 provides descriptive statistics on several innovation related indicators for the UK for the period 1995-2007.

Table 17: Innovation related indicators for the period 1995-2007

Year	*Number of companies receiving VC investment*	*Venture Capital disbursements (£m)*	*Number of companies receiving early stage VC investment*	*Early stage VC disbursements (£m)*	*Business R&D Expenditure (£m)*	*Government R&D Expenditure (£m)*	*Employment in R&D (000s)*	*Employment in HRST (000s)*	*Patent application (EPO)*	*Patents granted (UKPO)*	*Ratio of Venture Capital to R&D*
1995	n.a	2140	n.a.	n.a.	9118	2042	145	n.a.	93	n.a.	0.23
1996	1106	2806	n.a.	n.a.	9298	2070	141	n.a.	219	n.a.	0.3
1997	1178	3066	n.a.	n.a.	9555	2017	137	10016	2014	n.a.	0.32
1998	1147	3775	288	288	10133	2078	147	n.a.	3542	n.a.	0.37
1999	1109	6169	347	427	11303	1788	151	10427	4960	n.a.	0.55
2000	1182	6371	394	703	11510	2135	145	10765	5268	2934	0.55
2001	1307	4752	383	390	12239	1829	153	10942	5016	2642	0.39
2002	1196	4480	373	295	12485	1752	159	11160	4882	3203	0.36
2003	1274	4074	427	263	12506	2067	156	11544	5044	3540	0.33
2004	1301	5336	454	284	12661	2168	148	12088	5180	3670	0.42
2005	1307	6813	491	382	13734	2288	146	12314	4812	3661	0.5
2006	1318	10227	500	946	14560	2313	147	12862	2676	2933	0.7
2007	1330	11972	502	434	16109	2238	163	13296	n.a.	2028	0.74
2008	1278	8556	455	360	n.a.	n.a.	n.a.	13985	n.a.	2042	n.a

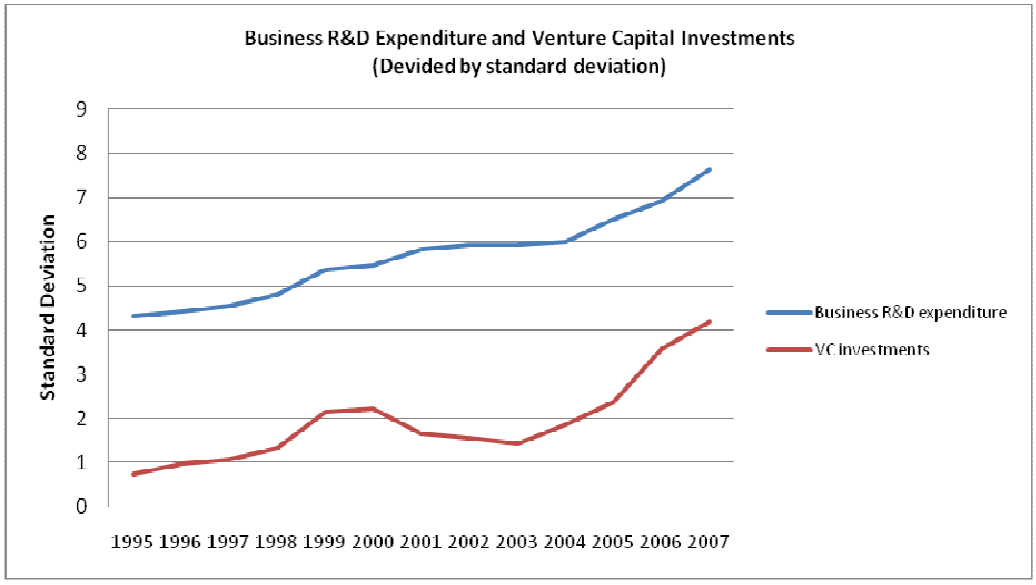
Source: BVCA, ONS, Eurostat; Note: All figures are in millions of 2008 pounds. The ratios of venture capital disbursement to R&D expenditure are computed using all venture capital disbursement only.

Table 17 illustrates that the number of companies receiving venture capital investments (including early stage companies) has remained relatively stable since 1995, although the amounts invested have been dramatically increased, indicating large investment deals. Business R&D spending has increased during the last decade while government R&D spending remained relatively stable as well as employment in R&D. Employment in science and technology is steadily increasing.

Table 17 also shows that the patent count declined since 2004 (patent applications and patents granted), reflecting the increasing importance of other forms of intellectual property protection such as licenses and design trademarks.

The final column of Table 17 shows the ratio of venture capital to Business R&D Expenditure. The ratio between venture capital disbursements and Business R&D expenditure has been constantly increasing from 0.23 in 1995 to 0.74 in 2007. This mainly reflects the higher annual increase in VC disbursements compare with the increase in business R&D expenditure. Figure 27 illustrates the trends in venture capital investments and business R&D expenditure for the period 1995-2007.

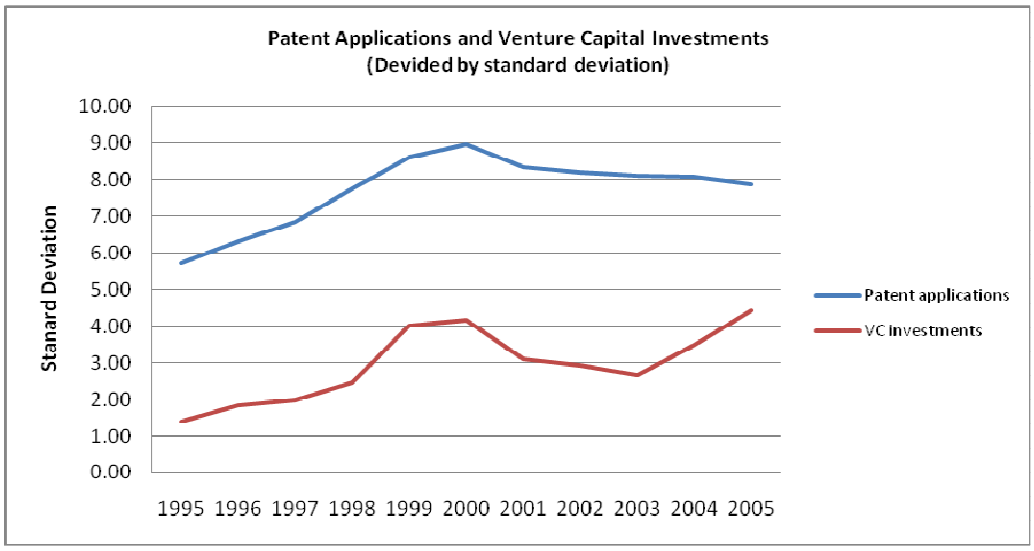
Figure 27: Trends in venture capital investments and business R&D expenditure, 1995-2007



Source: BVCA, ONS

A shown in Figure 27, the two measures, Business R&D Expenditure and VC investments seem to be partially correlated. More particularly, between 1995-2000 and 2005-2007 there seems to be a close correlation. However, during the period 2001-2004 the VC investments experienced a significant decline driven by the crisis in dotcom businesses , while business R&D expenditure continued (although modestly) to increase.

Figure 28: Trends in Venture Capital investments and patent applications, 1995-2005



Source: Eurostat, BVCA

Figure 28 summarizes the time series of VC investments and number of patent applications. VC investments show a rapid increase during the dotcom era (1999-2000) and then declined until 2003. Since then, VC investments have rapidly increased. Figure 28 also shows a reduction of EPO (European Patent Office) patent applications since 2000, but show no signs of recovery unlike the VC market. The two series appear to be closely correlated before 2003 but show no signs of correlation after 2003. This may be due to the fact that there has been an increase in other forms of copyright protection and the decline in EPO patents reflects the increase in license, trademarks and other forms of intellectual right protection.

Together with the observation between VC investments and Business R&D expenditure (Figure 27), it is clear that there is a relationship between VC investments and innovation as expressed by number of patent applications and Business R&D expenditure. However, this relationship is not always positive or strong.

Unlike the time series data in Figures 27 and 28, a clear and positive relationship between VC investments and several indicators of innovation is observed in cross-sectional data (Table 18). Correlations coefficients are widely used as measurements of relationship between two independent indicators. Table 18 examines how related venture capital activity is with several innovation indicators using one observation for each region for each year.

Table 18: Correlations between venture capital and innovation related indicators

	Number of companies receiving VC	*Venture Capital disbursements (£m)*	*Number of companies receiving early stage VC*	*Early stage VC disbursements (£m)*	*Business R&D Expenditure (£m)*	*Government R&D Expenditure (£m)*	*Employment in R&D (000s)*	*Employment in ST (000s)*	*Patent applications*	*Patents granted*
Venture Capital disbursements (£m)	0.78	1.00								
Number of companies receiving early stage VC	0.91	0.66	1.00							
Early stage VC disbursements (£m)	0.76	0.78	0.73	1.00						
Business R&D Expenditure (£m)	0.49	0.23	0.67	0.47	1.00					
Government R&D Expenditure (£m)	0.69	0.42	0.76	0.61	0.74	1.00				
Employment in R&D (000s)	0.53	0.23	0.68	0.45	0.95	0.76	1.00			
Employment in ST (000s)	0.94	0.72	0.87	0.73	0.57	0.76	0.60	1.00		
Patent applications	0.91	0.60	0.83	0.68	0.64	0.79	0.69	0.92	1.00	
Patents granted	0.82	0.45	0.78	0.58	0.68	0.79	0.75	0.83	0.93	1.00

Source: BVCA, ONS, Eurostat

Table 18 reports correlations between several innovation related indicators and VC (amounts of venture capital invested, amounts of early stage venture capital invested, business R&D expenditure, employment in R&D sectors, number of people employed in R&D sectors, number of patent applications and patents granted). Business R&D expenditure and VC investments correlations are all positive and high on many occasions. More particularly, Business R&D expenditure is closely related to venture capital activity with the highest coefficient with the number of companies that receive early stage finance (0.67). Government R&D spending is closely related with all the expressions of venture capital activity with - surprisingly – often higher coefficients compared with the business R&D spending. The number of companies receiving VC finance is closely related to business R&D and government R&D expenditure with coefficients of 0.49 and 0.69 respectively. Employment in science and technology is more closely related to the VC activity (number of companies and investments) compared with employment in R&D. Patents (applications and granted) are more closely related to the number of VC companies than VC invested amounts. This is mainly due to the fact that total amounts invested per year can be easily skewed by large amounts invested. As expected there is a very close relationship between employment in Science and Technology and R&D.

The observations suggest that, at the cross-sectional level, there is a positive association of VC activity with innovation as expressed by Business R&D expenditure, patent applications and patents granted. In what follows, this claim is examined in more detail at the regional level using regression analysis.

6.3.2 The relationship between VC activity and regional innovation outputs: A regional regression analysis

The strong relationship between venture capital and patenting as illustrated above, is indicative of a relationship between venture capital activity and innovation output. A natural next step is to identify how significant this relationship is. In order to answer this question it is necessary to deploy a form of regression analysis and measure the likely impact of VC investments on innovation as expressed by the volume of patent application and business R&D expenditure. This section is inspired by Kortum and Lerner (2000) who examined the influence of venture capital on patented inventions in the United States across twenty industries over three decades and found that increases in venture capital activity in an industry are associated with significantly higher patenting rates.

The following quantitative analysis aims to measure the relationship between venture capital and the inputs and outputs of innovation by exploring how variations in regions' inputs (venture capital investments) relate to variations in their outputs (patents and business R&D expenditure). As mentioned before Business R&D expenditure can be considered as an input of innovation and an output of VC investments (VC investments may spur more R&D spending), and for the purpose of this analysis it is treated as both innovation output and input.

Table 19 examines the relationship between venture capital activity and innovation (expressed by the number of patent applications and business spending on R&D) controlling for regional GDP and regional variations. The dependent variable is the number of patent applications instead of patents granted for two reasons. First, patent application is likely to be a better indicate of a company's willingness to innovate regardless of the outcome of its application. Second, there might be a significant time lag between filing an application and receiving a grant (Hall et al. 2001).

Venture capital activity is expressed as the amounts invested in each UK region and year using data from the British Venture Capital Association (BVCA). Region fixed effect (regional dummies that take the value 1 for each UK region) is used in order for the relationship between venture capital and innovation to be measured relatively to the average performance of a given region and year. For instance, if London has more VC investments than South East, the regression examines whether these two regions perform better or worse over time as compared with the average performance of

VC investments across all regions, and whether the variations in performance are more or less dramatic.

Table 19: Relationship between venture capital, patent application and business R&D at the region level

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Patent Applications (log)	Patent Applications (log)	Patent Applications (log)	Business R&D (log)	Business R&D (log)	Business R&D (log)
VC investments (log)	0.395	0.423	0.356	0.477	0.068	0.046
	(4.48)***	(2.15)*	(2.48)**	(3.38)***	(2.01)*	(1.76)*
Business R&D (log)	0.603	3.930	-0.290			
	(7.33)***	(3.55)***	(0.32)			
GDP (log)			7.570			0.870
			(6.55)***			(5.37)***
Patent applications (log)				0.182	0.068	-0.002
				(3.05)**	(3.13)***	(0.07)
Constant	-0.440	-9.968	-38.809	1.269	2.457	-2.032
	(1.66)	(3.10)**	(9.86)***	(4.80)***	(25.42)***	(2.32)**
Regional fixed effects	NO	YES	YES	NO	YES	YES
Observations	117	117	117	129	129	129
R-squared	0.36	0.52	0.74	0.54	0.97	0.98

Robust t statistics in parentheses
* significant at 10%, ** significant at 5%, *** significant at 1%
London is the reference region
Columns 1-3, includes data for 1995-2004 and columns 4-6 includes data for 1995-2008

Table 19 Column (1) shows regression coefficients for the natural log of the number of patent application to the natural log of venture capital investments and the natural log of Business R&D expenditure. Both coefficients are positive and significant at 1 percent level. Column (2) presents the same regressors but this time controlling for regional variations. The results remain positive and significant but this time the coefficient for Business R&D expenditure increases, suggesting a stronger relationship between Business R&D and patent applications. When controlling for regional GDP, Column (3), such coefficient is no longer significant. However, the coefficient for VC investments remains positive and significant in all regressions, suggesting that there is a strong and positive relationship between patent applications and VC investments. However, this result has to be interpreted with caution since there may be an issue of multicollinearity (the correlation between VC investment and patent application is relatively high, see Table 18). Columns 4-6 show results of the business R&D regression with VC investment and patent application again controlling for regional GDP and regional variations. There is a positive and significant relationship between Business R&D expenditure and VC investments in all regressions, suggesting that increases in region VC activity levels are positively related with increases in the amount of Business R&D spending in a region.

These findings reinforce the argument of the importance of VC activity in regional innovation performance as it shows a strong relationship between venture capital and innovation. However, this relationship may also be explained by a third unobserved factor, the arrival of technological opportunities (Hall and Lerner 2010). Thus, there could be more innovation at times when more venture capital was available, not because the venture capital caused the innovation, but rather because the venture capitalists reacted to some fundamental technological shock which was likely to lead to more innovation (Hall and Lerner 2010). In this case, the innovative firms selected venture capital financing rather than venture capital fund enabled the firm to be more innovative, and therefore the role of venture capital in spurring innovation is questionable. To address this concern, Kortum and Lerner (2000) examined the possibility that venture capital backed firms are more keen to patent their inventions compared with no venture capital backed firms due to mainly two reasons: venture capital backed firms may fear that the venture investors will exploit their ideas and investors are keener to invest in companies with patents already granted. The latter explanation reserves reverse causality (cause and effect in reverse): since one of the criteria that venture capitalists use to assess business proposal is the existence of patents, a company may deliberately acquire a patent in order to increase its chances of receiving VC capital. Therefore, the coefficient would be positive not because more VC investments lead to more patents, but because companies receive patents in order to receive VC funding. In order to address these issues, Kortum and Lerner (2000) examined three additional measures of innovation activity: i) the number of patent citations and the economic importance of a patent; ii) the frequency and extent of a patent; and iii) trade secret litigation in which a firm has engaged. All the tests of differences in means and medians in these three categories are significant at least at the five-percent confident level, as well as when they employed regression specifications, which indicate that venture capital indeed spurs innovation. Given the rapid increase in venture funding since 1992 in the US, the report suggested that by 1998 venture funding accounted for about 14 percent of U.S. innovative activity. The results of the regression analysis in Table 19 should be seen in relation to the findings of Kortum and Lerner (2000) which although conducted at the industry level and in the US, nevertheless provides strong evidence on the likely impact of VC in innovation activity.

The next section deploys disaggregated data at the firm level aiming to reveal specific characteristics of the individual investments such as industry, stage and location and also to examine whether different types of VC investments have a potentially different impact on innovation and how this is reflected at the regional level.

6.4 Firm level analysis

To address these issues it is necessary to employ a different research design which puts the firm at the centre of analysis instead of the region. Using a combination of commercial databases and publicly available information, a data set was constructed that allows several characteristics of the VC backed companies (amounts received, funding rounds, patent applications etc.) to be observed. The main strength of the database is that it distinguishes between private and publicly backed venture capital investments. The database also provides information on industry operation and the geographical base of the companies. Using this database it is possible to investigate two issues:

First, does the relationship between venture capital and patents become stronger as the venture capital investment journey progresses? Or in other words, are companies with patents more likely to secure follow up VC finance compared with companies without patents (hypothesis 2)? Companies may be geared up to receive patents even after their first finance round in order to increase their likelihood to receive further VC funding in follow up rounds. In addition, companies with patents may be more likely to receive follow up VC investment compared with companies without patents. One might expect to observe a large heterogeneity in the volume of patent applications across companies operating in different industries. Similarly, due to regional characteristics and the specific industrial focus of some regions, one would expect to observe large regional variations in the volume of company patent application.

Second, analysis in previous sections shows that there are now two distinctive source of VC finance since publicly backed investment have become an important source of finance especially at the early stage level. It has also been demonstrated that some regions are particularly dependent on publicly backed funds as the main source of VC finance, while other regions are better connected with private funds. In the light of this development a natural question is raised: *Do different sources of venture capital affect the relationship between VC and innovation outputs in different ways?* Answering this question will provide evidence for research question 3 of this thesis: *Are public funds less effective in investing in companies with the potential to innovate, than the private funds?*

6.4.1 Limitations

This analysis has several important limitations. First, the time when the company was granted or applied for the patent is not known. Therefore, it is not possible with the given data to examine whether the patent was granted or applied for before or after the VC investment. Therefore the aim of the research is not to investigate the role of VC investments in promoting innovation within the

company. Rather the aim of this research is to examine the association between venture capital investments and patents within the investment journey and the role of the source of finance in supporting companies with patents (or the ability to acquire patents). A future study could capture the date of patent application and associate it with the date of VC investment. Second, the quality of the patents has not been accessed. Patents backed by publicly backed funds may be of better quality of those backed by private funds or the opposite. Lerner et al. (2008) research on patent quality (using number of citations as a proxy for economic importance) found that patents applied by firms in private equity transactions are more cited, and such research could be undertaken within the framework of a follow up study. Third, patents have been used as a proxy for innovation. Although the literature accepts that patent creation is an important figure for innovation, additional proxies for innovation could be used in future analysis such as licenses, trademarks, number of new products in the market, copyrights etc. Forth, additional depended variables could be used in future analysis such as the performance of the VC backed companies and its association with patent and public or private investment. In this sense, performance could be defined as company turnover, employment growth etc. Finally, a further research could control for other characteristics of the firm that may affect its innovation outputs, such as size of firm, foreign ownership, export activity, openness, structure, R&D activity etc.

It is important to note that the reported statistical analysis is not adequate to distinguish between the possibility that patents facilitate progress through the investment cycle and the possibility that the investment has facilitated the firm's ability to apply for patents. This issue is nicely explained by Mann and Sager (2007):

''on one hand, venture financing contributes to the ability of start-up firms to apply for patents in several ways; the venture capitalist facilitates patenting both by providing funds and by providing management expertise to assist the portfolio firm in the development process. On the other hand, the interviews reported in Mann (2005a) suggest that patents (or the prospect of patents) often can be useful in obtaining funding. Most obviously, patents can solve one of the most difficult problems for a start-up: convincing the venture capitalist that the start-up can sustainably differentiate itself from its competitors. Similarly, as the firm advances through the venture capital cycle, patents often are useful to protect the firm against larger incumbent firms that might try to drive the start-up from the market. Many investors also value patents because of information they convey about the operational competence of the firm's management" (Mann and Sager 2007, p. 200).

6.4.2 Patents and venture capital investment journey

A venture capital backed company normally receives several rounds of finance called funding rounds. Each time a company needs new finance (for example in order to launch a new product, to conduct new trails etc.), it raises a new round. This happens until the company is ready to exit through an IPO or a Merger or Acquisition. Some companies need only few rounds before exit while others need several. Companies that are not able to raise further funding rounds are normally acquired or cease operations. A venture capital fund may take part in one or several funding rounds. Table 20 presents the number of VC backed companies that had one or more patents or patent applications at each funding round.

Table 20: VC investment made to companies

Funding Rounds	Number of investments made to companies without patent	Number of investments made to companies with patent	Total	Proportion of investments made to companies without patent	Proportion of investments made to companies with patent
(1)	(2)	(3)	(4)	(5)	(6)
1	1,496	687	2,183	69%	31%
2	572	465	1,037	55%	45%
3	208	291	499	42%	58%
4	81	147	228	36%	64%
5	39	68	107	36%	64%
6	13	21	34	38%	62%
7	6	9	15	40%	60%
8	2	7	9	22%	78%
9	0	3	3	0%	100%
10	0	2	2	0%	100%
Total	2,417	1,700	4,117	59%	41%

Column (1) of Table 20 includes funding rounds from one to ten. Because the structure of venture capital financing gives venture capitalists a realistic opportunity to terminate firms after each round, and makes each additional round a substantial indicator of progress, the number of rounds is also a good proxy for performance (Gompers and Lerner 2001; Mann and Sager 2007). Column (2) shows

the number of investments that were made to companies that had no patents or patent applications, and column (3) shows companies that had one or more patents or patent applications. Column (4) shows the total number of companies that received funding in each funding round (from 1 to 10). The last two columns of the table present these figures in percentages.

2,183 investments from the sample were made to companies at the 1st funding round. 687 or 31 percent of them were made to companies with one or more patents. From the 1,037 investments in round 2, approximately half (45 percent) were made to companies that had one or more patents at the time of investment. In later funding rounds the proportion of investments that were made to companies with patents exceeds 60 percent. It is clear that the percentage of investments that is made to companies with patents rises as the funding of the company progresses. This clear relationship between funding rounds and patents is in line with the literature as it confirms that a patent is an important factor in venture capital finance. For example, Hellmann and Puri (2000) found that firms earning more patents are more likely to obtain VC funding and it is apparent that patents appear increasingly important to the business of VC-backed firms (Kaplan et al. 2009). Haeussler et al. (2009) found that patenting is important for the general VC investment decision and that they help firms to attract VC faster than would be possible without patents. However, this finding is open to two interpretations: First, companies are more likely to progress to the next level of funding if they have a patent or second, companies acquire patents during their investments journey. As the dataset does not include information on patent applications dates, it is not possible to investigate the latter potential interpretation. Therefore, it is not possible to provide an answer to the question as to whether the company applied for a patent before or after the investment was made, which could have provided some clues as to the role of VC finance in encouraging the business to acquire patents.

Since no information was obtained on firms that have never received VC finance, this section does not examine the question whether patents are important in order to secure first round finance. Rather it examines the question whether patents relate to subsequence investment decisions.

Table 21 investigates the relationship between the source of finance (public or private) and patents.

Table 21: Descriptive statistics

	Public deals			Private deals		
Round	N	No of deals with patents	%	N	No of deals with patents	%
1	837	267	31.9%	1346	420	31.2%
2	339	146	43.1%	698	319	45.7%
3	143	74	51.7%	356	217	61.0%
4	60	36	60.0%	168	111	66.1%
5	29	17	58.6%	78	51	65.4%
6	14	8	57.1%	20	13	65.0%
7	5	2	40.0%	10	7	70.0%
8	3	2	66.7%	6	5	83.3%
9	2	2	100.0%	1	1	100.0%
10	0	.		2	2	100.0%
	1432	554	38.7%	2685	1146	42.7%

Around 68-69 percent of all first round investments (public or private) were made to companies without a patent and the remaining 31 to 32 percent to companies with a patent. However, in later stage deals, it is clear that a higher proportion of private investments were made to companies with patents compared with the public investments. This trend is better observed in a graphical illustration.

Figure 29: Patents by stage and source of finance

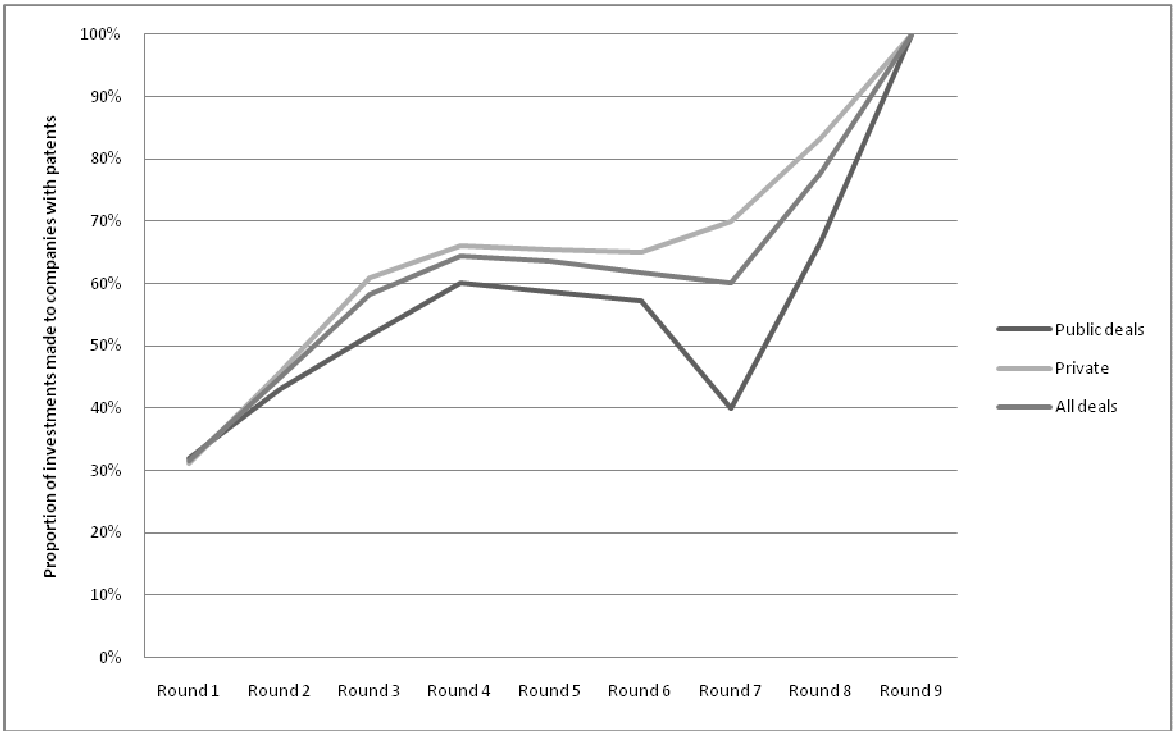


Figure 29 graphically presents the proportion of investments made to companies with patents during the investment journey, from the first until the final round. While only 31 to32 percent of first investments made by either private or public funds are made to companies with patents, as the investment's journey progress, public funds become less geared towards investing in companies with patents compared with their private counterparts. The convergence at the very latest rounds may be explained by the very small number of investments made.

The sequence analysis investigates how significant these differences in patents between public and private investments are at the regional level controlling for various factors that may affect the presence of patents such as, where the company is based, in which industry it operates, from where it receives VC finance, the amounts it receives and the stage of finance. For example, the differences outlined above may be skewed by some regions with large number of investments or a focus on an industry that does not require patents.

6.4.2.1 Source of finance

Table 22 presents descriptive statistics of the 4,117 investments included in the study sample. The investments are presented by source of finance and are broken down into three categories (Public, Private and Business Angels). Data on the size of the individual investments were not always available. Data on patents have been collected using the EPO (European Patent Office) on line database (see chapter 4 for details).

Table 22 : Investments by source of finance

	All				
	N	Mean	Std Dev	Min	Max
Year	4117	2004	2.45	2000	2008
Amounts	3173	2978.14	5454.03	4	60000
Rounds	4117	1.85	1.21	1	10
Patents	4117	0.41	0.49	0	1

	Publicly backed deals				
	N	Mean	Std Dev	Min	Max
Year	1467	2005	2.10	2000	2008
Amounts	1098	732.46	1459.86	4	21600
Rounds	1467	1.72	1.13	1	9
Patents	1467	0.38	0.49	0	1

	Private deals				
	N	Mean	Std Dev	Min	Max
Year	2579	2004	2.54	2000	2008
Amounts	2008	4175.45	6415.64	8	60000
Rounds	2579	1.90	1.22	1	10
Patents	2579	0.42	0.49	0	1

	Business Angels deals				
	N	Mean	Std Dev	Min	Max
Year	692	2005	2.17	2000	2008
Amounts	597	1937.83	4158.47	20	60000
Rounds	692	1.93	1.27	1	9
Patents	692	0.46	0.50	0	1

Investment characteristics. The average size of a VC investment in the study sample is £2978k, but there is considerable heterogeneity between different source of finance. In the overall sample the

smallest investments is £4k and the largest one is £60m. The average size of investments in which public funds participate in is £732k, private funds £4.18m and Business Angels £1.94m.

The average funding round of the sample was 1.85, 1.72 for Public funds, 1.90 for Private funds and 1.93 for Business Angels. This is not surprising as Public funds face several constraints in follow up investments (NESTA 2009). Forty one percent of the investments in the sample were made to companies with patents. Thirty eight percent of investments in which a Public fund participated were made to companies with patents, 42 percent when only Private funds participated and 46 percent when a Business Angel participated.

The sample contains investments that were made between 2000 and 2008 and the average investment in the sample was made in 2004. Average Public funds and Business Angel investment was made in 2005 while Private fund investments was made in 2004.

Forty one percent of all investments in the sample were made to companies with patents. Thirty eight percent of investments in which one or more public fund participated were made to companies with patents (or patent applications). Forty two percent of investment in which only private funds participated were made to companies with patents (or patent applications).

Publicly backed investments can be further broken down into two categories: investments made by solely Private Funds (Solely Private); and, investments in which one or more in which one or more private sector investors has invested alongside one or more public sector funds (Co-investments).

Table 23: Descriptive Statistics – Financial source of publicly backed funds

	Co-investments						Solely Public				
	N	Mean	Std Dev	Min	Max		N	Mean	Std Dev	Min	Max
Year	811	2005	1.96	2000	2008	Year	651	2005	2.20	2000	2008
Amounts	621	1046.15	1815.39	5	21600	Amounts	473	325.48	570.85	4	7500
Rounds	811	1.92	1.26	1	9	Rounds	651	1.47	0.88	1	7
Patents	811	0.48	0.50	0	1	Patents	651	0.27	0.44	0	1

Investment characteristics. The average size of a co-investment is £1046 and the smallest investment is £5k and the largest one is £21.6m. The average size of investments in which solely public funds participate in is £325k, the smallest investment is £4k and the largest one is £7.5m. The small average size of a solely public investment reflects the limited ability of the public funds to invest large amounts (NESTA 2009).

The average funding round of a co-investment is 1.92 and for solely public investment is 1.47. Again this reflects the constraints that public funds face in following up investments.

Forty eight percent of the co-investments in the sample were made to companies with patents. Only 27 percent of investments in which only public fund participated were made to companies with patents.

6.4.2.2 Industry variations

Table 24 presents the industry characteristics of the 4,117 investments included in the study sample. Once again, the investments are presented by source of finance and are broken down into three categories (Public, Private and Business Angels). The last column of each table presents the proportion of the deals that this particular source invested in each industry.

Table 24: Descriptive statistics – Industry and source of VC

Private deals

Industry	Obs	Mean	Std. Dev	Min	Max	No of deals	% of deals
Unknown	422	0.75	0.44	0	1	315	0.12
Consumer & Business	436	0.65	0.48	0	1	283	0.11
Energy	46	0.72	0.46	0	1	33	0.01
Finance	51	0.91	0.28	0	1	47	0.02
Healthcare	252	0.51	0.50	0	1	128	0.05
ICT	737	0.63	0.48	0	1	463	0.17
Leisure Goods	23	0.52	0.51	0	1	12	0.00
Manufacturing & Industrial	315	0.54	0.50	0	1	170	0.06
Media	156	0.67	0.47	0	1	104	0.04
Pharmaceuticals & Biotechnology	494	0.62	0.49	0	1	308	0.11
Software & Computer Services	1185	0.69	0.46	0	1	822	0.31
Total	4117					2685	

Public deals

Industry	Obs	Mean	Std. Dev.	Min	Max	No of deals	% of deals
Unknown	422	0.25	0.44	0	1	107	0.07
Consumer & Business	436	0.35	0.48	0	1	153	0.11
Energy	46	0.28	0.46	0	1	13	0.01
Finance	51	0.09	0.28	0	1	4	0.00
Healthcare	252	0.49	0.50	0	1	124	0.09
ICT	737	0.37	0.48	0	1	274	0.19
Leisure Goods	23	0.48	0.51	0	1	11	0.01
Manufacturing & Industrial	315	0.46	0.50	0	1	145	0.10
Media	156	0.33	0.47	0	1	52	0.04
Pharmaceuticals & Biotechnology	494	0.38	0.49	0	1	186	0.13
Software & Computer Services	1185	0.31	0.46	0	1	363	0.25
Total	4117					1432	

Business Angels

Industry	Obs	Mean	Std. Dev.	Min	Max	No of deals	% of deals
Unknown	422	0.22	0.41	0	1	93	0.13
Consumer & Business	436	0.14	0.34	0	1	59	0.09
Energy	46	0.17	0.38	0	1	8	0.01
Finance	51	0.11	0.31	0	1	5	0.01
Healthcare	252	0.22	0.41	0	1	55	0.08
ICT	737	0.18	0.38	0	1	132	0.19
Leisure Goods	23	0.04	0.21	0	1	1	0.00
Manufacturing & Industrial	315	0.19	0.39	0	1	60	0.09

Media	156	0.12	0.32	0	1	18	0.03
Pharmaceuticals & Biotechnology	494	0.17	0.38	0	1	85	0.12
Software & Computer Services	1185	0.15	0.36	0	1	176	0.25
Total	4117					692	

In absolute terms, more private investments are made to every single industry compared with any other source of VC finance but this is driven by the largest number of private deals compared with the publicly backed. Perhaps the most interesting column is the last, which presents the proportion of deals that were made by each source to each particular industry. Eleven percent of both private and public investments and 9 percent of Business Angel investments went to Consumer & Business. Only 1 percent of all types of investment went to companies operating in Energy. Finance companies attracted 2 percent of all private investments, 1 percent of Business Angels and almost none from public funds investments. Healthcare companies received 5 percent of all private deals, 9 percent of all public deals and 8 percent of Business Angels deals. Companies operating in ICT sector attracted 17 percent of all private deals, 19 percent of all public and Business Angel deals, making ICT the second most preferred sector for VC investments.

One percent of public investment went to companies operating in Leisure Goods while private funds and Business Angels invest even less. Manufacturing & Industrial attracted 6 percent of private and 10 percent of public investment and 9 percent of Business Angels. Four percent of private and public and 3 percent of Business Angel investments were made to Media companies. Pharmaceutical companies attracted 11 percent of all private, 13 percent of all public and 12 percent of all Business Angels investments. Finally, Software & Computer services attracted 31 percent of all private and 25 percent of all public and Business Angel investments making it the most preferred sector of investment for all types of VC finance.

Interestingly, there are differences in terms of sector preferences between private and public VC funds such as Software and Computer companies where private funds allocated 6 percent more of their total investment compared with the public fund. In contrast, Public funds invest 4 percent more of their total investments to Manufacturing and Industrial and Healthcare companies, compared with the Private funds. How significant these differences are is something that will examine in a later stage of this chapter.

6.4.2.3 The relationship between industry and investment characteristics

Table 25 presents correlations between industry sectors and number of patents, publicly backed investment deals, size of investment deals, financing rounds and Business Angels involvement in the deal.

Table 25: Correlations between deal characteristics and industry

	Patents	Private investments	Public Investments	Co-investments	Solely public	Business Angels	Size of deal	Number of round
Patents	1							
Private investments	0.01	1						
Public Investments	-0.04	-0.96	1					
Co-investments	0.06	-0.64	0.67	1				
Solely public	-0.13	-0.56	0.58	-0.21	1			
Business Angels	0.04	-0.14	0.14	0.34	-0.19	1		
Size of deal	0.07	0.29	-0.30	-0.17	-0.20	-0.09	1	
Number of round	0.23	0.05	-0.08	0.03	-0.14	0.03	0.12	1
Consumer & Business	-0.19	-0.02	0.03	0.00	0.04	-0.03	-0.01	-0.11
Energy	0.07	0.02	-0.02	0.00	-0.03	0.00	0.04	-0.01
Finance	-0.07	0.07	-0.07	-0.04	-0.05	-0.01	0.15	-0.06
Healthcare	0.07	-0.07	0.07	0.07	0.01	0.04	-0.06	0.02
ICT	0.22	-0.01	0.00	0.02	-0.03	0.02	0.03	0.15
Leisure Goods	-0.04	-0.02	0.02	-0.01	0.03	-0.03	0.06	-0.03
Manufacturing & Industrial	0.06	-0.07	0.08	0.04	0.06	0.02	-0.09	-0.04
Media	-0.12	0.02	-0.01	-0.04	0.02	-0.03	-0.02	-0.08
Pharmaceuticals & Biotechnology	0.22	-0.05	0.01	0.01	0.00	0.01	0.07	0.08
Software & Computer Services	-0.21	0.09	-0.08	-0.06	-0.04	-0.03	-0.03	-0.04

Patents. Table 25 shows that several industries are closely correlated with patents. For instance, in the first correlation, the coefficient of 0.21 between ICT and patents and 0.22 between Pharmaceutical and Biotechnology and patents, implies that VC backed companies that operate in these two sectors are more likely to have a patent compared with other sectors. In contrast, companies operating in Software & Computer Services, Consumer & Business and Media are less likely to have a patent. The stage of investment (number of round) is also positively correlated with patent (0.23) reflecting the relationship between patent and later stage deals as examined earlier. Interestingly, investments made by solely public funds are negatively correlated with patents and this relationship will be examined further in the next sections.

Source of investments. Private investments are positively associated with the size of the deal (0.29) which is not surprising since private funds are much larger than public and invest larger amounts,

while public investments are negatively associated (-0.30). Similarly, private investments are positively associated with larger funding rounds, while public investments are negatively associated. Interestingly, private investments are negatively associated with Business Angels (-0.14), perhaps reflecting the fact that Business Angels normally participate in small investments, while Public investments are positively associated (0.14). Industry wise, several differences between private and public investments are observed with the most noticeable ones, in Software & Computer Services, Finance, Manufacturing & Industrial and Healthcare.

Size of deal. General Financial is positively associated with higher amounts of deals followed by the Pharmaceutical sector to a much lower extent. Companies operating in Chemical, Mobile Telecommunication, Pharmaceutical and Biotechnology sector also received larger amounts compared with those operating in other sectors.

Number of funding rounds. Although the differences are quite small amongst industries, companies in the Pharmaceutical & Biotechnology sector followed by Electronics & Equipment and Mobile Telecommunications seem to attract slightly more funding rounds than companies from other sectors, reflecting the larger amounts that they receive. In contrast, Media and Support Services companies seem to attract fewer number of funding rounds compared with companies from other sectors. Interestingly, companies in these two sectors are the most unlikely to have a patent as shown earlier.

Business Angels involvement in the deals. Technology Hardware & Equipment together Industrial Engineering and Healthcare Equipment & Services are more closely associated with investment deals in which one or more business angel has participated. In contrast, companies from the Support Services and Mobile Telecommunication are less likely to have patents.

6.4.2.4 The relationship between size of deals and regions

Table 26 reports summary statistics for the explanatory variables size of investments and number of funding rounds. This table tests for differences in sample means between each region and London in terms of size of venture capital deal and number of funding rounds that a company receives. The table includes all deals with disclosed amounts. The number of observations is as recorded in the second column.

Table 26: Tests for differences in the means of size of deal and funding rounds, 2000-2008

	Size of investments deal				Number of funding rounds			
	N	Mean	Difference with London	*P*-value	N	Mean	Difference with London	*P*-value
West Midlands	158	1758.33	-1962.14	0.000	234	1.65	0.002	0.983
Wales	95	2560.97	-1159.8	0.068	119	1.79	0.093	0.128
South East	593	3682.73	-38.037	0.913	724	1.93	0.286	0.000
South West	200	3027.54	-693.233	0.118	257	1.93	0.286	0.000
Scotland	309	2485.33	-1235.442	0.001	445	2.15	0.498	0.000
North West	217	1782.82	-1935.953	0.000	291	1.71	0.065	0.302
North East	99	1073.96	-2646.809	0.000	120	1.63	0.091	0.801
N Ireland	41	2214.39	-1506.378	0.102	52	1.65	0.006	0.824
Yorkshire	165	1634.35	-2086.417	0.000	199	1.6	-0.045	0.807
East England	416	3597.79	-122.977	0.719	544	2.25	0.598	0.000
East Midlands	101	1265.97	-2454.798	0.000	132	1.58	-0.065	0.456
London	734	3720.77			1000	1.65		
Total	3128	2978.14			4117	1.85		

* Equal variances assumed

Highly significant differences amongst the 12 UK regions are observed. London has the highest average amount of investment per deal (£3,720k) while the North East has the lowest (£1,073k). The average size of investment deal in the whole country for the years 2000-2008 is £2,978k. West Midlands, North West and Yorkshire average size of investment deals is about 50 percent smaller than in London (significant at the 1 percent level). Average deal size in Wales and Scotland is about 30 percent and in North East 70 percent smaller than in London.

Although London based companies are more likely to receive larger investment, the average number of financing rounds that they receive is one of the lowest in the country (1.65). In contrast, companies based in the South East, South West, Scotland and East of England received more funding rounds than those based in London. More particularly, companies based in East England and Scotland are more likely to receive a follow up round (significant at the 1 percent level) than companies based in any other UK region.

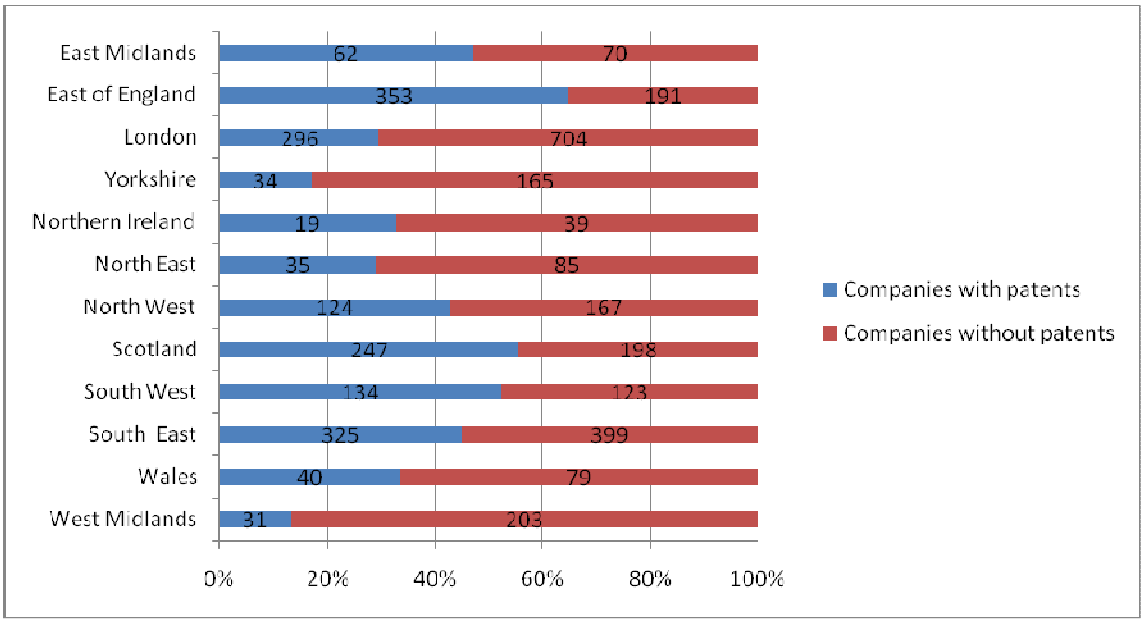
East of England companies receive the second highest average amount of funding and more funding rounds than companies based in any other region, making East of England the most attractive region for companies seeking VC investments.

These findings show that the characteristics of the deals vary substantially between the UK regions. Overall, the observed differences appear to document an edge of East of England, London and South East investments deals over the remaining regions.

6.4.3 The relationship between patents and regions

Figure 30 examines the geography aspect by measuring the volume of patents for companies that received VC investments at each particular region and shows that there are significant differences amongst UK regions. Figure 29 illustrates the proportion (and the number) of VC investments that were made to companies with and without patents for the period 2000-2008.

Figure 30: Proportion of investments that were made to companies with and without patents, 2000-2008



Over 60 percent of all VC deals that took place in the East of England were made to companies that had one or more patents (or had applied for one) during 2000-2008. Over 50 percent of investments that took place in Scotland and South West and over 40 percent of investments that took place in East Midlands, South East and North West were made to similar companies. In contrast, only a small proportion of investments were made to companies with patents that were located in London, Northern Ireland, North East and Wales (approximately 30 percent) and even smaller proportion to companies located in West Midland and Yorkshire (below 20 percent).

Approximately half of all VC backed companies located in Scotland and East Midlands have one or more patents. In contrast, the vast majority of VC backed companies located in West Midlands, Yorkshire and London do not have any patents. These findings are open to three interpretations:

First, it may suggest that venture capital funds allocated in those two regions do not consider patents as a priority in investments decision making. Second, these regions do not contain a sufficient pool of investable companies with patents or that companies in these regions operate in industries that do not require patents. Third, it may also mean that companies in these regions receive more follow up investments (i.e. a larger number of individual deals were made to the same companies) and consequently, it appears that more investments are made to companies with patents.

Table 27 presents the proportion of patents by different type of investments (private, public, co-investment and solely public) broken down by region.

Table 27: Proportion of patents by region and source of finance

All deals

Region	Obs	Mean	Std.
East Midlands	132	0.48	0.50
East of England	544	0.66	0.48
London	1000	0.30	0.46
N Ireland	52	0.37	0.49
North East	120	0.29	0.46
North West	291	0.43	0.50
Scotland	445	0.56	0.50
South East	724	0.45	0.50
South West	257	0.52	0.50
Wales	119	0.34	0.47
West Midlands	234	0.13	0.34
Yorkshire	199	0.17	0.38

Private deals

Region	Obs	Mean	Std.
East Midlands	61	0.52	0.50
East of England	429	0.66	0.47
London	847	0.28	0.45
N Ireland	22	0.41	0.50
North East	29	0.28	0.45
North West	160	0.51	0.50
Scotland	165	0.63	0.48
South East	568	0.44	0.50
South West	161	0.58	0.49
Wales	54	0.31	0.47
West Midlands	73	0.15	0.36
Yorkshire	82	0.21	0.41

Public deals (deals involving one or more public investments)

Region	Obs	Mean	Std.
East Midlands	71	0.44	0.50
East of England	115	0.63	0.48
London	153	0.41	0.49
N Ireland	30	0.33	0.48
North East	91	0.30	0.46
North West	131	0.34	0.48
Scotland	280	0.52	0.50
South East	156	0.47	0.50
South West	96	0.42	0.50
Wales	65	0.35	0.48
West Midlands	161	0.12	0.33
Yorkshire	117	0.15	0.35

Co-investment deals (deals involving one or more public investment and one or more private investments)

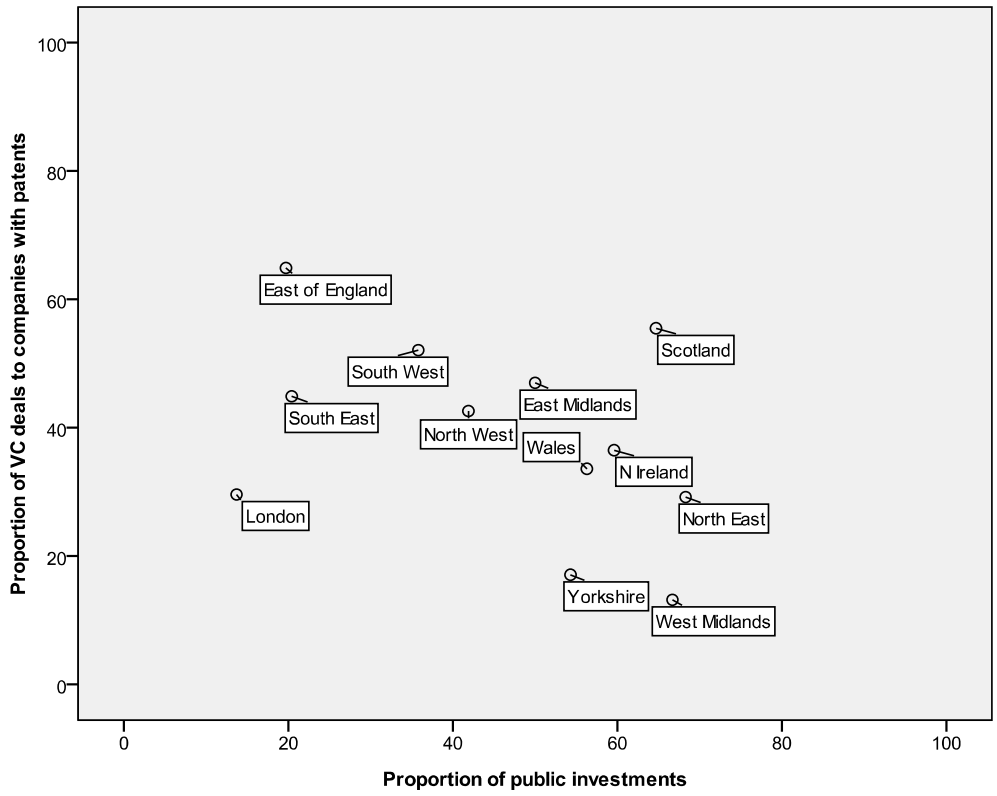
Region	Obs	Mean	Std.
East Midlands	32	0.63	0.49
East of England	57	0.70	0.46
London	85	0.54	0.50
N Ireland	24	0.29	0.46
North East	49	0.33	0.47
North West	49	0.39	0.49
Scotland	245	0.53	0.50
South East	89	0.62	0.49
South West	51	0.53	0.50
Wales	29	0.45	0.51
West Midlands	59	0.17	0.38
Yorkshire	46	0.20	0.40

Solely public deals (deals involving only investments made by publicly backed funds)			
Region	Obs	Mean	Std.
East Midlands	39	0.28	0.46
East of England	58	0.55	0.50
London	68	0.24	0.43
N Ireland	6	0.50	0.55
North East	42	0.26	0.45
North West	82	0.30	0.46
Scotland	35	0.43	0.50
South East	67	0.28	0.45
South West	45	0.29	0.46
Wales	36	0.28	0.45
West Midlands	102	0.10	0.30
Yorkshire	71	0.11	0.32

6.4.4 The relationship between investment characteristics and regions

Figure 31 visually presents the relationship between VC investments made to companies with patents (or companies that had applied for patents) and publicly backed investments. Regions with high dependency on public investments such as the North East, West Midlands, Northern Ireland and Wales, also have low proportion of VC investments made to companies with patents. In contrast, regions with high level of VC investments to companies with patents such as East of England, South West and South East, are less depended on publicly backed investments.

Figure 31: Source of finance and regions



At a first glance this visual illustration may indicate that publicly backed venture capital fund investments could be related to the negative performance in terms of patents production from VC backed companies of those regions. However, there may be other factors influencing the lower performance of patent production in each region. These are: First, and foremost, the relationship observed in the graph may be explained not because of the extensive public involvement but by the domination of the early stage deals in these regions (which as shown earlier are not associated with patents to the same extent as the later stage deals are). Second, publicly backed funds based in these regions do not encourage companies to get a patent once invested. Third, companies in these regions may be operating in sectors that do not require a patent and consequently the VC funds can only choose amongst the companies without patents.

Is the difference between the observed proportions significantly large to indicate a genuine difference in the ability between public and private funds to invest in companies with the potential to innovate, or it could have arisen simply as a consequence of experimental variation when in fact there is no underlying difference? In order to investigate all these issues a regression framework analysis is conducted.

6.5 Regression analysis – Source of venture capital and potential of firms to innovate

A substantial amount of research has been conducted into the question of what likely impact the VC has in the innovation performance of a company (Gompers and Lerner 2001). However, little is known about the potential impact that different types of VC finance (e.g. publicly backed VC funds and Business Angel) have on innovation. In particular, do public funds and Business Angels invest in companies that have the potential to innovate in the same extent as private funds do? Do they perform better or worse compared with their private counterparts in identifying and investing in such companies?

This section investigates *whether there is an association between different types of investments (publicly backed, private or Business Angel investments) and company patents.* The analysis examines a variety of factors that may affect the existence of patents (or patent applications) within a company such as stage of development, industry operation and year of investment as shown earlier.

In order to explore whether the relationships uncovered by visually examining the data in the previous section, are statistically significant as well as not driven by other factors not captured in the previous graphs, it is necessary to conduct a regression analysis. Several regression models have been estimated to analyse the likely ability of publicly backed funds to spur innovation as expressed by the existence of patents (or patent applications) while accounting for characteristics of the investment deal, such as size and stage, and the industry.

As previously discussed, most existing empirical work emphasizes the poor financial performance of the publicly backed funds (NAO 2009, NESTA and BVCA 2009). This section aims to address a new question that has not received much attention in the literature, namely the potential role that publicly backed investments play in spurring innovation.

6.5.1 The impact of different source of VC investments in company's innovation outputs: A multivariate sub-regional analysis

This section examines several factors that may affect the innovation performance of a firm using two models of regression analysis, Ordinary Least Squares (OLS) and Probit regression. For the subsequent analysis individual investments at the company level is used as the unit of analysis, that is, each investment to a single company is treated as a separate observation. The analysis regresses the presence of a patent in a company on a dummy for publicly backed fund involvement in the deal,

and control variables for industry specialisation, size, funding round and the geographical location of the company.

6.5.2 Estimation technique

Multivariate statistical techniques, such as Probit regression analysis, enable the analysis to take account of the complexity of the factors associated with the use of VC investments, and to investigate the interrelationships between variables (see Johnson et al. 2007). The large size of the database and the range of information collected allows such an analysis to be performed. In doing so it is possible to build a picture of the type of VC investments that are most (and by implication least) likely to spur or support innovation in the investee firm.

The models used are estimated through ordinary least squares and Probit regression analysis. Because the outcome variable is binary (either the company has a patent or does not), it is necessary to use a model that handles this feature correctly. Therefore the Probit regression model has been chosen.

The individual firm operates in a sector which might have similar characteristics. An obvious extension, therefore, would be to integrate sector heterogeneity in order to allow for a degree of dependency within sectors and then to estimate the usual model parameters with sector effects (Johnson et al. 2007). Therefore, the regression model is reconsidered in order to take into account sectoral heterogeneity that may be attributable to the sector in which the firm is operating. Regional dummies are also included in order to take into account regional variations. Previous analysis identified that they are significant differences between sectors and regions in terms of the likelihood of a VC backed company to have a patent. Companies operating in particular sector (e.g. finance industry) are by definition less likely to create patents compared with other sectors (e.g. pharmaceuticals). Therefore, it is important to ensure that the selected model controls for sector effects in order to avoid drawing erroneous conclusions (Johnson et al. 2007).

6.5.3 Extending the analysis to incorporate cluster effects – firm level analysis

A possible limitation of the above analysis is that the OLS and Probit regressions implicitly assume that each of the units of observation (investment deals) included in the sample is random. However, this is not the case as firms normally attract more than one investment deal. A firm for example can receive one investment from a solely public fund and another from a solely private fund or from a syndication of public and private funds. The standard binary Probit model ignores any potential firm

unobserved heterogeneity. For example, in the case of firm level data, unobserved heterogeneity could reflect management ability or strategy (Harris et al. 2003).

Therefore, the units of observation (investment deals) could be clustered according to firm, as otherwise using standard Probit estimation may produce biased results. As the data in the database were collected at the investment level, it is possible to cluster them according to the firm in which these deals were made. The solution to this problem is to use a model in which the degree of dependency within clusters is jointly estimated with the usual model parameters (Johnson et al. 2007). In order to estimate the model, maximum-likelihood estimator (Probit) that incorporates clustering to control for heterogeneity has been used. The clustered estimates allow the analysis to gauge the significance of the unobserved individual effects as well as the extent of the inconsistency in the random estimates when the individual effect and some of the regressors are correlated (Amuedo-Dorantes and Kimmel 2005).

The clustering of firms in this way might be a significant improvement over other types of estimation and may control for the heterogeneity such as the difference in probability of a firm possessing or applying for a patent to different firms in different sectors.

The data available contains an innovation status variable (0 = no patent, 1 = patent) that measures whether the firm that received the investment has or has applied for a patent. This is a proxy for the "potential" of the firm to innovate. Innovation potential (patent) is therefore the dependent variable. The independent variables are two types of investments: public and private. London is the omitted category from the set of UK region dummies.

Table 28: OLS and Probit estimates of factors affecting patents creation – Public investments

Dependent variable: Patent

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dummies for different type of investments: (comparison category is investment made by private funds)	OLS				Probit				Marginal effects in probability
Public investments	-0.052	-0.025	0.006	-0.020	-0.135	-0.066	0.016	-0.074	-0.028
	(3.26)**	(1.00)	(0.23)	(0.76)	(3.25)**	(0.98)	(0.21)	(0.90)	-1.17
Business Angel Investments	0.062	0.051	0.035	0.027	0.158	0.133	0.098	0.082	0.032
	(2.95)**	(1.87)	(1.35)	(1.04)	(2.98)**	(1.88)	(1.36)	(1.00)	1.16
Size of deal		0.000	0.000	0.000		0.000	0.000	0.000	0.071
		(1.52)	(1.49)	(1.24)		(1.45)	(1.47)	(1.20)	(7.54)***
Number of round		0.085	0.074	0.056		0.226	0.208	0.181	0.001
		(9.37)**	(6.85)**	(5.14)**		(8.23)**	(6.23)**	(4.89)**	1.57
Regional dummies									
West Midlands			-0.187	-0.244			-0.639	-0.891	-0.294

			(3.51)**	(4.57)**			(2.99)**	(3.88)**	-8.21
Wales			0.055	0.004			0.149	0.016	0.006
			(0.70)	(0.05)			(0.70)	(0.06)	0.1
South East			0.095	-0.034			0.254	-0.133	-0.051
			(2.31)*	(0.70)			(2.31)*	(0.92)	-1.44
South West			0.210	0.104			0.559	0.286	0.113
			(3.66)**	(1.92)			(3.64)**	(1.74)	(2.52)**
Scotland			0.228	0.130			0.605	0.377	0.149
			(4.70)**	(2.71)**			(4.60)**	(2.60)**	(3.86)***
North West			0.091	0.045			0.250	0.138	0.054
			(1.57)	(0.89)			(1.63)	(0.89)	1.25
North East			0.003	-0.086			0.015	-0.291	-0.11
			(0.04)	(1.14)			(0.07)	(1.22)	(-1.97)**
N Ireland			0.013	-0.057			0.038	-0.163	-0.062
			(0.11)	(0.54)			(0.12)	(0.51)	-0.76
Yorkshire			-0.149	-0.264			-0.487	-0.914	-0.3
			(2.84)**	(4.96)**			(2.56)*	(4.42)**	(-8.89)***
East England			0.300	0.144			0.791	0.397	0.157
			(6.57)**	(3.20)**			(6.12)**	(2.85)**	(4.55)***
East Midlands			0.189	0.083			0.507	0.226	0.089
			(2.64)**	(1.36)			(2.71)**	(1.21)	1.46
Industry dummies									
Energy				0.510				1.561	0.493
				(5.52)**				(4.95)**	(12.51)***
Finance				0.042				0.198	0.078
				(0.46)				(0.58)	0.68
Healthcare				0.389				1.212	0.433
				(7.08)**				(6.59)**	(12.39)***
ICT				0.416				1.276	0.469
				(9.72)**				(8.09)**	(14.52)***
Leisure Goods				0.143				0.365	0.144
				(0.95)				(0.59)	0.82
Manufacturing & Industrial				0.395				1.248	0.444
				(7.54)**				(6.95)**	(13.27)***
Media				0.004				-0.029	-0.011
				(0.07)				(0.10)	-0.16
Pharmaceuticals & Biotechnology				0.481				1.480	0.515
				(10.44)**				(8.68)**	(18.03)***
Software & Computer Services				0.102				0.381	0.15
				(2.74)**				(2.56)*	3.74
Year fixed effects	No	No	Yes	Yes	No	No	Yes	Yes	
Constant	0.424	0.267	0.168	0.061	-0.192	-0.608	-0.901	-1.363	
	(42.41)**	(11.87)**	(4.38)**	(1.46)	(7.52)**	(9.65)**	(8.01)**	(8.44)**	
Observations	4117	3173	3173	2857	4117	3173	3173	2852	
R-squared	0.00	0.05	0.13	0.26					

Robust t statistics in parentheses

* significant at 10%, ** significant at 5%, 1% significant

Reference region is London, and reference industry Consumer and Business

Table 28 presents the results from the ordinary least squares and clustered Probit estimations. The dependent variable in both types of regression is whether the company has a patent or has applied for a patent, and the independent variables in both type of regressions is investments made by public funds. The table contains the results from the two preliminary models. Models 1-4 produce OLS estimates while Modes 4-8 Probit estimates.

Columns (1) and (5) provide significant coefficients for the independent variables (although quite small). When controlling for the size of the deal and the number of the round of the deal (Columns 2 and 6) the coefficients are no longer significant. Similarly when dummies for the industry and the region (Columns 3, 4, 7 and 8) are added, the coefficients continue to be insignificant. As a result, after controlling for the size and round of the investment, sector and region, the initial results suggest that the type of finance (public or private) may not be associated with the company's potential to innovate. However, there may be another interpretation of these results: the publicly backed funds may play a passive role in the investment syndication and it is the private funds that are responsible for picking companies with potential to innovate and public funds just follow. In order to investigate this issue further, all publicly backed investments are separated into two groups, solely public investments and co-investments (between private and public funds).

The independent variables are now three types of investments: Investments solely made by publicly backed funds (Solely Public); investments made by solely Private Funds (Solely Private); and, investments in which one or more in which one or more private sector investors has invested alongside one or more public sector funds (Co-investments). Solely Public, Co-investments and Business Angels take the value 1 if they participated in the deal in question and 0 otherwise.

Table 29: OLS and Probit estimates of factors affecting patents creation – Solely public investments and co-investments

Dependent variable: Patent									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dummies for different type of investments: (comparison category is investment made by private funds)	OLS				Probit				Marginal effects in probability
Solely public investments	-0.167	-0.143	-0.097	-0.103	-0.456	-0.395	-0.295	-0.352	-0.134
	(8.33)***	(4.57)***	(3.03)***	(3.13)***	(7.78)***	(4.37)***	(3.04)***	(3.15)***	(3.15)***
Co-investments	0.045	0.064	0.084	0.047	0.114	0.166	0.236	0.137	0.054
	(2.14)**	(2.13)**	(2.80)***	(1.61)*	(2.15)**	(2.14)**	(2.84)***	(1.51)*	(1.51)*
Business Angel investments	0.005	-0.004	-0.010	-0.012	0.012	-0.009	-0.027	-0.037	-0.015
	(0.21)	(0.13)	(0.37)	(0.44)	(0.21)	(0.12)	(0.36)	(0.44)	(0.44)
Size of deal		0.000	0.000	0.000		0.000	0.000	0.000	0.000
		(1.28)	(1.32)	(1.09)		(1.21)	(1.31)	(1.04)	(1.04)
Number of round		0.082	0.072	0.054		0.219	0.202	0.177	0.069
		(9.16)***	(6.75)***	(5.07)***		(8.07)***	(6.14)***	(4.83)***	(4.83)***
Regional dummies									
West Midlands			-0.174	-0.233			-0.607	-0.856	-0.285
			(3.25)***	(4.35)***			(2.79)***	(3.70)***	(3.70)***
Wales			0.062	0.011			0.178	0.035	0.014
			(0.80)	(0.14)			(0.84)	(0.15)	(0.15)
South East			0.094	-0.034			0.254	-0.134	-0.052
			(2.32)**	(0.70)			(2.31)**	(0.93)	(0.93)
South West			0.210	0.105			0.561	0.288	0.114
			(3.66)***	(1.94)*			(3.63)***	(1.75)*	(1.75)*
Scotland			0.206	0.113			0.546	0.324	0.128
			(4.24)***	(2.35)**			(4.14)***	(2.23)**	(2.23)**
North West			0.105	0.057			0.294	0.179	0.071
			(1.86)*	(1.15)			(1.94)*	(1.15)	(1.15)
North East			0.005	-0.084			0.023	-0.283	-0.107
			(0.06)	(1.11)			(0.11)	(1.18)	(1.18)
N Ireland			-0.022	-0.085			-0.059	-0.251	-0.095
			(0.20)	(0.81)			(0.19)	(0.78)	(0.78)
Yorkshire			-0.132	-0.249			-0.450	-0.878	-0.291
			(2.55)***	(4.73)***			(2.37)**	(4.26)***	(4.26)***
East England			0.302	0.147			0.805	0.411	0.163
			(6.65)***	(3.28)***			(6.20)***	(2.94)***	(2.94)***
East Midlands			0.199	0.092			0.543	0.261	0.104
			(2.85)***	(1.56)			(2.92)***	(1.42)	(1.42)
Industry dummies									
Energy				0.504				1.542	0.491
				(5.51)***				(4.91)***	(4.91)***
Finance				0.039				0.189	0.075
				(0.42)				(0.55)	(0.55)
Healthcare				0.388				1.206	0.432
				(7.13)***				(6.53)***	(6.53)***
ICT				0.416				1.273	0.468
				(9.76)***				(8.08)***	(8.08)***
Leisure Goods				0.137				0.344	0.136
				(0.92)				(0.56)	(0.56)
Manufacturing & Industrial				0.393				1.236	0.442
				(7.49)***				(6.84)***	(6.84)***

Media				0.009				-0.032	-0.013
				(0.16)				(0.12)	(0.12)
Pharmaceuticals & Biotechnology				0.481				1.483	0.517
				(10.53)***				(8.68)***	(8.68)***
Software & Computer Services				0.104				0.379	0.149
				(2.79)***				(2.54)**	(2.54)**
Constant	0.433	0.286	0.177	0.066	-0.170	-0.563	-0.876	-1.338	
	(43.07)***	(12.67)***	(4.64)***	(1.59)	(6.66)***	(9.00)***	(7.83)***	(8.27)***	
Year fixed effects	No	No	Yes	Yes	No	No	Yes	Yes	
Number of clusters (companies)		1879	1879	1679		1879	1879	1679	
Observations	4117	3173	3173	2857	4117	3173	3173	2852	
R-squared	0.02	0.06	0.14	0.27	0.01	0.05	0.11	0.22	
Log likelihood					-2754.87	-2073.53	-1943.38	-1532.89	

Robust t statistics in parentheses

* significant at 10%, ** significant at 5%, *** significant at 1%

Reference region is London, and reference industry Consumer and Business

Table 29 presents the results from the ordinary least squares and clustered Probit estimations. The dependent variable in both types of regression is whether the company has a patent or has applied for a patent, and the reference category in both types of regressions is investments solely made by Private funds. The table contains the results from the two types of regressions models. Columns (1) to (4) produce OLS estimates while columns (5) to (8) Probit estimates. Column (9) provides marginal increase probabilities which measure the change in probability of the dependent variable to a change in the independent variable implied by the Probit coefficients evaluated at the sample mean (Hellman and Puri 2000).

It is worth noting that Probit coefficients are higher than the OLS. The results of the OLS and Probit analysis suggest that, in general, investments solely made by Public funds are less likely to be made to companies with the potential to innovate compared with those made by Private funds. In addition, the R squared and pseudo R squared has been systematically increasing when adding extra variables, allowing more power to the analysis.

Column (1), suggests that there is a strong and negative association between companies that received solely Private investments and patents, and a strong but positive association between companies that received Co-investments and patents. More particular, solely Public investments were made to companies with significantly lower likelihood (or potential) of having a patent. The Co-investments variable have positive and statistically significant coefficient (although quite small) for the OLS model. The coefficients become higher and remain significant when using the probit model in column (5). The coefficients for Business Angel are very small and statistically insignificant in both models.

Columns (2) and (6) include two investment-specific controls which is the number of the round when the investment took place and the size of the investment. The main results described above are not affected by the inclusion of these controls. The coefficient for the number of the round is positive and significant reflecting the fact observed earlier that later stage rounds are more likely to happen in companies with patents. Interestingly, the direct effect of the size of the investment is not significant indicating that it has no effect on the likelihood of a company having a patent.

Columns (3) and (7) include dummies for the region in which the company operates. The coefficients remain remarkably stable. There is strong evidence of regional effect suggesting that the location of the firm is important. The geographical location of the companies is significantly associated with patents in several regions.

Columns (4) and (8) include dummies for the industry that the company operates in. The results remain unchanged and highlight the importance of the influence of sectoral heterogeneity in assessing the factors associated with the innovation performance of a firm.

It is worth noting that the reported results have a relatively low explanatory power. This is not surprising (see Mann and Sager 2007), since venture capital backed firms might perform well or poorly for reasons that have nothing to do with patents.

''it is important to take account of the low explanatory power in trying to understand what the data suggest about the real world of investment decision making and venture-backed firm performance'' (Mann and Sager 2007, p.200).

Overall, the results suggest that solely Public investments are strongly and negatively associated with the potential of a firm to have a patent. The marginal effect in the likelihood is -13.4 percent, which is significant at 1 percent (see Column 9). This suggests that obtaining solely Public investment is associated with a significant decrease in the likelihood of company to have a patent or to have applied for one. In contrast, obtaining Co-investments is associate with an increase in the likelihood of the company to have a patent (5.4 percent) compared with those that receive investment from Private funds. It appears that the likely effect of the type of VC finance increases with respect to the existence of patent (or patent application), suggesting that companies that receive investments from a syndicate of public and private funds hold or produce more patents than companies that receive investments from solely publicly backed funds. This is in line with prior literature which suggest that enterprises with moderate government venture capital support, outperform enterprises with only private venture capital support and those with extensive government venture capital support in terms of patent creation (Brander et al. 2010).

The results of this analysis suggest a strong association between the source of VC finance of the firm and the innovation potential of the firm. These results provide valuable guidance to public policy makers concerned with venture capital investments and innovation, and suggest a number of avenues for future research.

6.5.4 Additional tests

One of the caveats of this research is that the database only includes investments made to UK firms between 2000-2008. This means that the database contains some firms that receive only one investment during this period, either because this investment was the last one (and took place for example in 2000 or the first one and took place in 2008). Similarly, other firms received only two investments during this period. In order to control for this effect, an additional analysis (not reported here) has been performed with a restricted sample of companies with more than three investments. Companies were grouped according to the type of the majority of the investments they received: solely publicly supported companies, syndication support companies and solely privately supported companies. Four hundred companies where identified using this methodology. The regression analysis confirmed the findings from the above analysis.

All the investments have been also partitioned into first round investments which include only companies that received first round investment but no follow up investments. 676 companies were identified using this methodology. This sample allows one to observe whether the company had a patent (or had applied for one) at the time of its first investment. For this purposes, a new variable was created which is a dummy and which takes the value 1 when a company received only one investment and this was the first round investment, and the value 0 otherwise. The results of this analysis (not reported here) also confirm the findings from the previous analysis.

6.5.5 Summary results

The results consistently indicate that there is a strong and negative association between companies that received Solely Public investments and patents, and a strong but positive association between companies that received Co-investments and patents.

This is in line with Hochberg et al. (2007)'s comment on the importance of investment syndication:

"syndication relationships are a natural starting point not only because they are easy to observe, but also because there are good reasons to believe they affect the two main drivers of VC's performance,

namely, the ability to source high-quality deal flow and the ability to nurture investments (i.e. add value to portfolio companies)'' (Hochberg et al. 2007, p. 252).

This could also provide some explanation on the negative relation between solely public funds investments and patents, due to the fact that such funds quite often do not invest in syndicate and therefore miss out the added value that a syndicate brings into the deal.

These findings support the hypotheses that were set out drawing on the likely relationship between the different source of VC finance and the company's innovation potential and suggesting that ''the potential of a company to innovate (expressed as the ability of a company to acquire a patent) is associated with the source of VC finance (public or private).'' To summarize the results, first, a company is more likely to keep receiving VC finance if it has a paten (or it has applied for one). Second, if a company does not have a patent, it is more likely to get later stage finance from public rather than from private funds.

There are several interpretations of the results of this analysis that can only be explained by additional analysis. For example, the positive relationship between co-investment and patents could be potentially explained by the fact that venture capitalists that take part in a syndicated deal between public and private funds receive more deal proposals from patent oriented sources (universities, research institutes or laboratories). To investigate all these possible explanations a survey of venture capital professionals from the public and private sector operating in early stage VC industry has been conducted. The following chapter presents the findings of the survey and revisits the findings of the empirical analysis to cross-check previous findings.

6.6 Conclusions

This chapter aimed to test three different hypotheses. Hypothesis one was concerned with the relationship between VC activity and volume of innovation. More particularly, the analysis aimed to examine whether increases in venture capital activity, expressed as number of deals or invested amounts, is positively associated with increases in volume of innovation, expresses as number of patent application and business R&D expenditure.

A strong and positive relationship between VC activity and volume of innovation is observed in cross-sectional data analysis. VC invested amounts and the number of companies receiving VC finance is closely related to patents creation and business R&D expenditure. Unlike the cross-sectional data analysis, the results of the time series data analysis is less clear. The graphical analysis shows a relationship between VC investments and innovation as expressed by number of patent

applications and Business R&D expenditure, but this relationship is not always positive or strong. To investigate this relationship further and to quantify the effect of VC on volume of innovation, a regression framework analysis is deployed. The results of this analysis reinforce previous suggestions that there is a strong relationship between venture capital and innovation.

The second hypothesis of this chapter posited that companies with patents are more likely to secure follow up VC finance compared with companies without patents**.** To test the previous hypothesis, the country or region was the unit of analysis. To test hypothesis two it was necessary to deploy a different level of analysis which allowed for the investigation of such a hypothesis in great detail: the firm level analysis.

An important finding of this analysis, which is in line with the literature and with the findings of hypotheses one and two, is that there is a clear relationship between VC and patents. Companies that have one or more patents (or patent applications) are more likely to receive follow up investments compared with companies without patents. As the funding progresses to sequence rounds, companies with patents are more likely to proceed to follow up investments (subject to noted caveats).

Due to the importance of patents in the VC investments, the analysis examined whether there are any factors that may affect the company's possession of a patent, such as where the company is located, industry operation, source of VC finance, amounts received and stage of finance. The results of this analysis show that there are significant variations between companies that operate in different industries. Several industries have significant higher number of patents. For instance, VC backed companies from the Pharmaceutical and Biotechnology sector are more likely to have a patent compared with other sectors. Similarly, companies operating in Technology Hardware and Equipment, Electronic & Electrical Equipment, Mobile Technology, Healthcare Equipment and Services sector are more likely to have a patent. In contrast, Software & Computer Services, Media, Support Services, General Retailers, General Financial and Travel & Leisure companies are less likely to have a patent at the time of investment.

The geography aspect and the volume of patents for companies that received VC investments in each particular region has also been examined and showed that there are significant differences amongst UK regions. More particularly, over sixty percent of all VC deals that took place in East of England were made to companies that had one or more patents during 2000-2008. Over 50 percent of Investments that took place in Scotland and the South West were made to companies with patents while over 40 percent of investments that took place in the East Midlands, the South East

and the North West were made to companies with patents. In contrast, only a small proportion of investments were made to companies with patents that were located in London, Northern Ireland, North East and Wales (approximately 30 percent) and an even smaller proportion to companies located in the West Midlands and Yorkshire (below 20 percent). This finding may suggest that either venture capital funds allocated in those two regions do not consider patents as a priority in investments decision making or that these regions do not contain a pool of sufficient pool of investable companies with patents or that companies in these regions operate in industries that do not require patents.

The findings of this chapter posited that the potential of a firm to innovate (expressed as the ability of a firm to acquire a patent) is associated with the source of VC finance (public or private). By identifying the source of finance from each VC funds that participated in the 4117 deals of the sample database it was possible to examine the relationship between source of VC finance and innovation performance of the firm. The results of this analysis show that there is a statistically significant relationship between patents and the source of finance. This raises two questions: why this may be the case and why does it matter?

This statistically significant and negative association between solely publicly backed investments and the firm's potential to innovate remains strong, even after controlling for a variety of factors associated with sectoral structures or investments characteristics: differences between regions, industry focus, investments size or investments stage. This suggests that this relationship is the result of some unmeasured investment characteristics or the environment in which funds operate. The plausibility of this suggestion will be examined in the next chapter.

The analysis in chapter 5 illustrated that there are currently two distinctive VC markets in the UK regions, a privately driven market and a publicly driven one. The findings of this chapter suggest that publicly backed funds do not support innovation to the same extent that private funds do, when they invest alone, which has important implications for regional development. Innovative companies that are based in regions with high dependency on public VC funds may find it more difficult to raise VC finance compared with similar companies based in regions with a strong presence of private VC funds. As a result, such companies may decide to relocate to regions with active private VC markets. However, Mason (2007) suggests that companies move to what is called 'convergence' regions in order to benefit from European funding.

The alternative explanation for the negative relationship between solely publicly backed investments and companies with the potential to innovate suggests that this is due to the lack of innovative

companies in the region. However, this does not seem plausible. Private investments are more likely to be made to companies with the potential to innovate compared with solely public investments even in the regions with relatively low innovation capacity. For example, in the East Midlands, 52 percent of all private VC investments were made to companies with the potential to innovate and only 28 percent of solely public investments were made to similar companies. Again, this difference is not driven by the industry focus, size or stage of the investments.

There is also the possibility that savvy entrepreneurs positively discriminate in favour of private sector investors when making their choice of financial partner (NESTA 2009) and as a result, the pool of business from which public funds choose to invest is much smaller and of questionable calibre. It would be expected that this could be the case in regions where the private sector funds have substantial presence e.g. London, East of England and South East.

On the other hand, co-investments (when public and private funds invest together) are more likely to be made to companies with the potential to innovate than private or solely public investments. As a result, regions with proportionally higher volume of co-investments would also demonstrate a higher volume of VC backed companies with the potential to innovate. From a policy perspective, this finding suggests that from an innovation point of view, public free standing investments should be minimised while co-investments should be further encouraged.

In that respect, when a region is dominated by publicly backed funds, it would be hard for these funds to find co-investors from the private sector and therefore the amount of co-investments would be limited. Alternatively, public funds in publicly dominated regions should be encouraged to attract private investments from outside investors. They should be seen as the pipeline of valuable information about investable opportunities in peripheral regions to London and South East based private VC funds.

The following chapter examines the environment in which the two distinctive VC communities operate. It identifies characteristics associated with the operational framework of public and private VC funds that may be related to their ability to identify, invest and support companies with the potential to innovate.

7 CHAPTER 7: EXAMINING THE ECOLOGY OF INTERACTION BETWEEN THE INNOVATION AND FINANCE COMMUNITIES

7.1 Introduction

Chapter 7 examines the role of the venture capital community in embracing regional linkages and networks within the regional innovation system. It empirically maps the linkages and examines the extent of interaction between venture capitalists with other professionals of the regional innovation system. More particularly, this chapter studies the ecology of interaction between venture capital funds and other players of the innovation system by examining the responses to a survey completed by 50 UK based early stage venture capitalists. It measures the rate of interactions and explores their professional network of contacts in an attempt to understand the different regional environments in which venture capital funds operate. By examining the dynamics of the regional environment, the attitudinal and behavioural characteristics of the different types of venture capital funds (public or private) it is possible to provide some preliminary clues as to the factors that may influence the ability of different types of VC funds to identify and invest in companies with the potential to innovate, as identified in the previous chapter.

Chapter5 provided a detailed analysis of the regional breakdown of the size and the nature of the venture capital activity in the UK, showing that there are significant differences amongst UK regions in terms of size, activity and public involvement in the early stage VC industry. The majority of the regions are dependent on public support while few regions are dominated by private VC investments (London, East of England and South East). Chapter 6 illustrated that there is a close relationship between venture capital activity and innovation. It provided empirical evidence which suggests that the nature of the venture capital community is closely associated with the potential of the firm to innovate by showing that when investing alone, publicly backed funds are less likely to invest in companies with the potential to innovate compared with the private venture capital funds. In contrast, when investing in a syndication deal with private funds, they are more likely to invest in companies with potential to innovate compared with the private venture capital funds.

The subsequent analysis attempts to explain what may drive these observed differences in the ability of the VC funds to invest in companies with the potential to innovate, by examining the behavioural characteristics of the different types of venture capital funds. More particularly, it investigates the ecology of interactions between the venture capital community and other players of

the regional innovation community and examines whether the nature of the fund has any potential affect in their frequency of interactions and overall behaviour. It is well documented by various scholars that a necessary element for effective innovation systems is the interaction and networking between the various players of the system and almost by definition, maintaining strong ties requires frequent interaction (Sorenson and Stuart 2001). This chapter addresses the question as to whether the venture capital community follows this pattern and how it fits within the innovation system.

The empirical basis of this chapter is the completed questionnaires of 50 UK early stage venture capitalists. An extensive analysis of the questionnaire including descriptive statistics and bias controls can be found in chapter 4 , Research Methodology.

The type of interactions between venture capitalists and other players in the innovation system have been grouped into two categories. One category focuses on the interactions of the venture capitalists within the internal finance community which includes, portfolio firms, firms seeking equity finance, public and private venture capital funds, business angel networks and individuals and banks. The second category of indicators examines the interactions between the venture capitalists with other players of the regional innovation system, such as universities, other research institutes, RDAs, regional authorities, specialists, law companies, IP bodies, managers of incubators, companies based on incubators.

The first aim of this study is to measure how often UK venture capitalists interact with other players of the regional innovation system. Since the focus of the study is the early stage VC activity, the attention of this chapter is limited to those venture capitalists which engage in early stage financing of a technology and innovative start-ups. *Given the nature the industry, it is expected that venture capitalists interact with each other more often that they do with the main players of the regional innovation system i.e. Universities, R&D institutes, RDAs, incubators etc.*

Because both the pre-investment activities (opportunity identification and appraisal) and the post-investment roles (monitoring and the provision of value-added services) favour local investing (reference), *it is anticipated that there will be stronger linkages and interactions with actors within the region in which the funds are based.*

The second aim of this chapter is to investigate what parameters may influence the extent of such interaction. This will in turn inform Hypothesis 4 of this thesis: *It is expected that there will be differences in the way that venture capitalists interact depending on the nature of their funds and their size.* There is a belief that publicly backed venture capitalists would be keener to engage with the regional innovation community than the private venture capitalists, mainly due to their linkages

with their funding bodies (e.g. Government, RDAs, Universities etc.). Therefore the hypothesis is that *professionals from publicly backed funds have established active communication and networking with several local incubators, Business Angel networks, and universities, and they appear to be more active than their counterparts from the private sector (Hypothesis 4).*

The analysis presented in this chapter establishes a series of findings that contribute to the literature in economic geography. Its findings have implication for regional economic development policies as venture capital firms and Business Angels now play an important role in the UK economy. The venture capital industry plays an important role in the UK economy and the individual regions as examined in previous chapters. It is therefore necessary that policy makers acquire detailed knowledge of the functionality of the market.

7.2 Descriptive statistics

Following the analysis in the previous chapter, all funds that took part in the survey have been grouped into three categories, according to proportion of public money that they received. One group includes funds that received more than 50 percent of their assets from public bodies (solely public funds), second group, funds that receive between 1- 49 percent of their assets from public bodies (co-investment funds) and finally a third group which includes funds that are solely private and did not receive any finance from a public organisation (solely private funds).

7.2.1 Source of funds

The proportion of public money that each VC fund receives varies according to the particular government intervention. Fifty two percent of the venture capitalists that took part in the survey worked for a fund which received the majority of its assets from a public organisation (Regional development agency, European Union, University, Government department, Devolved administration, Regional authority), (Table 30). Thirty two percent of the venture capitalists worked in a co-investment fund (when a minority of the assets came from the public sector) and the remaining 16 percent of them were employed by a solely private VC fund.

Table 30: Proportion of funds under management received by a public body

Proportion of funds under management received by a public body *	Number of funds	%
0%	8	16%
Under 25%	6	12%
25-49%	10	20%
50-74%	11	22%
75-99%	3	6%
100%	12	24%
Total	50	100%

*Regional development agency, European Union, University, Government department , Devolved administration, Regional authority

Table 31: Sources of public finance

Funding body	Number of funds that received funding	%
Regional development agency	10	21%
European Union	22	46%
University	9	19%
Government department	19	40%
Devolved administration	3	6%
Regional authority	4	8%

The two main sources of public funding for the examined funds are the European Union and the Government departments, followed by RDAs and universities, regional authorities and develoved administrations[3] (Table 31). European Union funding may include ERDF and European Investments Fund money while the Business Innovation and Skills (BIS) department provides finance on behalf of the central government. Almost half of the publicly backed funds (46 percent) received some porportion of EU money (either though ERDF or EIF) and 40 percent of them received finance from the government. Generally, publicly backed funds receive finance from more than one public sources and the most common pattern in the sample is EU and Government co-investing in a fund.

[3] Some venture capitalist working in funds based in regions with devolved administration replied that they received their finance from government departments. Therefore, the two terms, government department and devolved administration should be treated as one.

7.2.2 Fund characteristics

Table 32: Fund size, portfolio companies revenue and co-investments

All funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Fund size	50	4.82	2.69	0	8
Proportion of portfolio companies generating revenue	45	39.62	29.52	0	100
Proportion of co-investments	45	74.67	28.11	0	100
Invested alongside*:					
Private funds	50	3.08	1.74	0	5
Public funds	50	1.14	1.32	0	5
Bank loans	50	0.78	1.17	0	4
Loan funds	50	0.26	0.56	0	3
R&D grant	50	0.88	1.15	0	5

Public funds

Variable	Obs	Mean	Std. Dev.		Max
Fund size	26	4.12	2.44	0	8
Proportion of portfolio companies generating revenue	23	39.91	30.17	0	100
Proportion of co-investments	24	79.38	31.11	0	100
Invested alongside:					
Private funds	26	2.88	1.66	0	5
Public funds	26	1.42	1.42	0	5
Bank loans	26	0.96	1.31	0	4
Loan funds	26	0.35	0.69	0	3
R&D grant	26	0.81	1.06	0	3

Co-investment funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Fund size	16	5.44	2.85	0	8
Proportion of portfolio companies generating revenue	14	40.36	30.60	10	100
Proportion of co-investments	13	62.31	24.12	20	100
Invested alongside:					
Private funds	16	3.06	1.95	0	5
Public funds	16	0.75	1.24	0	4
Bank loans	16	0.75	1.13	0	3
Loan funds	16	0.13	0.34	0	1
R&D grant	16	1.06	1.44	0	5

Private funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Fund size	8	5.88	2.80	1	8
Proportion of portfolio companies generating revenue	7	32.14	27.36	0	75
Proportion of co-investments	7	78.57	20.35	50	100
Invested alongside:					
Private funds	8	3.63	1.85	0	5
Public funds	8	0.88	1.13	0	3
Bank loans	8	0.25	0.46	0	1
Loan funds	8	0.25	0.46	0	1
R&D grant	8	0.75	0.89	0	2

*1=<20%; 2=21-40%; 3=41-60%; 4=61-80% and 5=81-100%

Fund size. The fund size variable is a categorical variable which takes values from 1 to 8 as follows: 1= <£5m, 2= £6m-£10m; 3= £11m- £20m; 4= £21m - £30m; 5= £31m - £40m; 6= £41m - £50m; 7= £51m - £100m; 8= >£100m. The average value of the fund size variable of the whole sample is close to 5 (4.82), between £31m-£40m. Public funds are much smaller than both co-investment and private funds.

Proportion of companies. This particular segment of the investments market that the study investigates - as highlighted in the research methodology chapter - is mainly concerned with companies at a very early stage of their development that do not normally generate revenue from sales at the time of the investment. This is also evident in Table 32. Only around forty percent of all

portfolio companies generate any revenue and in the case of portfolio companies from private funds, this proportion is even lower (32%), perhaps reflecting the greater risks that private venture capitalists are willing to take (Table 32: private funds). This results is not surprising. Companies seeking risk finance at this level, do not normally have revenues yet and entail high risk. At later stages of the VC industry, companies generate reveunes and therefore lower the risk of investments for the venture capitalists.

Proportion of co-investments and company revenue .As shown in chapter 5, co-investments is now the dominant way of investing in this segment of the market. Venture capitalists were asked to indicate the proportion of their investments that have been made together with other bodies. On average, seventy five percent of all deals that venture capitalists make are co-investment deals. Public and private funds have higher proportion of co-investment deals compared with the co-investment funds.

Preferred co-investors. Venture capitalists were also asked to state the proportion of their co-investments made with one or more of the following bodies (private funds, publicly backed funds, bank loans, fund loans and R&D grant). Their responses are analysed below.

Table 33: Preferred co-investor

Proportion of investments	**0%-20%**		**21%-40%**		**41%-60%**		**61%-80%**		**81%-100%**		Total	
Private VC fund	8	17%	6	13%	8	17%	9	19%	16	**34%**	47	98%
Public (publicly backed) VC fund	16	**52%**	4	13%	7	23%	2	6%	2	6%	31	65%
Bank Loan	10	**48%**	2	10%	8	38%	1	5%	0	0%	21	44%
Loan Fund	10	**91%**	0	0%	1	9%	0	0%	0	0%	11	23%
R&D Grant	11	**44%**	9	36%	4	16%	0	0%	1	4%	25	52%
Total											48	

The extent to which the venture capitalists co-invest with other finance bodies varies significantly. Private funds are by far the preferred co-investment partner and all but one of the venture capitalists that took part in the survey co-invest with private funds to some extent. For over half of them (53 percent) the majority of their co-investments (between 60 percent-100 percent) were made with private funds. Half of the venture capitalist polled co-invest with publicly backed funds but these investments count for a modest proportion of their co-investments portfolio (between 0-20 percent). Banks, loan funds and R&D grants constitute a small proportion of co-investments sources.

Preferred stage of investment. Venture capitalists that took part in the survey were asked to state the preferred stages of investment. Participants were able to make multiple choices.

Table 34: Preferred stage of development

	All funds			Public funds			Co-investment funds			Private funds		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Seed	50	0.48	0.50	26	0.46	0.51	16	0.44	0.51	8	0.63	0.52
Start up	50	0.64	0.48	26	0.58	0.50	16	0.69	0.48	8	0.75	0.46
Early growth	50	0.78	0.42	26	0.73	0.45	16	0.75	0.45	8	0.88	0.35
Late growth	50	0.32	0.47	26	0.19	0.40	16	0.50	0.52	8	0.38	0.52
Expansion	50	0.26	0.44	26	0.19	0.40	16	0.44	0.51	8	0.13	0.35

The most preferred stage of investments for the surveyed venture capitalist is the early growth (78 percent) followed by start-up (64 percent) and seed (48 percent). Later stages such as late growth and expansion are not preferred by public venture capital funds, mainly due to restrictions on the size of funding that is imposed.

Unsurprisingly, the majority of all venture capitalists in the study indicated that seed, early stage and early growth are their preferred stages of investments. Professionals from co-investment funds were keener in investing in late growth and expansion compared with their counterparts from the public or private funds, perhaps reflecting their larger size.

7.2.3 Source of deals

An important element of venture investing is the quality of business proposals. Venture capitalists receive business proposals in various ways e.g. from their colleagues from other publicly backed or private funds, Business Angels, personal contacts or from ambitious entrepreneurs who approach them directly. The executives and employees at funded companies may forward potential investment opportunities that they learn about through friends, relatives and co-workers (Sorenson and Stuart 2001). Venture capitalists were asked to indicate the proportion of their investments sources by the above bodies.

Table 35: Deal sources

	0%-20%		21%-40%		41%-60%		61%-80%		81%-100%		Response Count	
Other private VC funds	21	**48%**	18	41%	4	9%	1	2%	0	0%	44	96%
Other public (publicly backed) VC funds	29	**71%**	10	24%	2	5%	0	0%	0	0%	41	89%
Business Angel networks	31	**72%**	10	23%	2	5%	0	0%	0	0%	43	93%
Personal business contact	6	13%	23	**51%**	8	18%	7	16%	1	2%	45	98%
The entrepreneur approaches you directly	12	26%	16	**35%**	9	20%	6	13%	3	7%	46	100%
Total											46	

Table 35 clearly demonstrates that personal business contact is the main source of deals followed closely by the entrepreneur's direct approach to the investment fund. The least common way that venture capitalists source deals is through public funds and Business Angels. There are no significant differences in the hierarchy of deals sources amongst different type of venture capitalists (Table 36).

This is not surprising as individuals have greater confidence in information collected from trusted parties (Sorenson and Stuart 2001) and venture capitalists repeatedly finance investments that they learn about through referrals from close contacts, including entrepreneurs that the capitalist previously financed, fellow venture capitalists, family members, or friends (Fried and Hisrich 1994).

For the vast majority of them, Business Angel networks and publicly backed funds provided less than 20 percent of their deal sources. This important finding reconfirms the role of the personal relationships in the industry. These results again coincide with the claim that venture capitalists exploit their contact network to gain access to deals in new areas (Sorenson and Stuart 2001).

Table 36: Source of deals by type of fund

All funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Other private funds	45	1.71	0.79	1	4
Other public funds	42	1.40	0.66	1	3
Business Angel	44	1.36	0.61	1	3
Personal contact	46	2.43	0.98	1	5
The entrepreneur approached you directly	46	2.39	1.20	1	5

Public funds

Variable	Obs	Mean	Std. Dev.		Max
Other private funds	23	1.91	0.85	1	4
Other public funds	20	1.70	0.80	1	3
Business Angel	22	1.59	0.73	1	3
Personal contact	24	2.46	0.88	1	5
The entrepreneur approached you directly	24	2.21	1.28	1	5

Co-investment funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Other private funds	14	1.50	0.65	1	3
Other public funds	14	1.14	0.36	1	2
Business Angel	14	1.14	0.36	1	2

Private funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Other private funds	8	1.50	0.76	1	3
Other public funds	8	1.13	0.35	1	2
Business Angel	8	1.13	0.35	1	2

Personal contact	14	2.36	1.08	1	4
The entrepreneur approached you directly	14	2.64	0.93	1	4

Personal contact	8	2.50	1.20	1	4
The entrepreneur approached you directly	8	2.50	1.41	1	5

*1=<20%; 2=21-40%; 3=41-60%; 4=61-80% and 5=81-100%

Table 37: Correlation between sources of deals and type of funds

	Pubic fund	Co-investment fund	Private fund	Other private funds	Other public funds	Business Angel networks	Personal contact
Source of deals							
Other private funds	0.30	-0.18	-0.16	1			
Other public funds	0.39	-0.20	-0.25	0.58	1		
Business Angel networks	0.39	-0.26	-0.16	0.07	0.10	1	
Personal contact	0.03	-0.11	0.10	-0.14	-0.30	-0.16	1
The entrepreneur approaches you directly	-0.35	0.22	0.17	-0.43	-0.48	-0.25	0.32

A closer analysis of the survey results reveals that Business Angel networks and publicly backed funds are most frequent sources of deals for publicly backed funds rather than for private or co-investment funds. In contrast, personal contacts are more closely related to private funds. Interestingly, the above tables suggests that the entrepreneur approaches directly co-investment or private funds much more often that he or she approaches public funds. Public funds are more likely to source their deals from Business Angels or other public funds than private or larger funds are. It is also very unlikely that the entrepreneur will approach a public fund directly as he or she would prefer to approach co-investment and private funds.

7.2.4 Industry focus

According to the literature, venture capital funds normally invest in sectors that have high growth potential. Venture capitalists were asked to choose the industries they prefer to invest in and the results of their responses are illustrated below.

The most preferred industry for investments is software where 72 percent of the venture capitalist polled chose it as one of their preferred sectors of investments (Figure 32). The second most preferred industry is medical devices and equipment (64 percent), followed closely by electronics/instrumentation (58 percent) and industry/energy (56 percent). Financial services and retail/distribution are the least preferred sectors of investments with 10 percent and 16 percent response rate respectively. Interestingly, the top three sectoral preferrences are the same in all examined types of funds.

Venture capitalists from public funds expressed their interest in several sectors, on average, these professional selected over half of all sectors (0.56). In contrast, venture capitalists from the private funds selected only few sectors (0.27) indicating that they are more specialised than their counterparts from the other type of funds.

Figure 32: Preferred industry

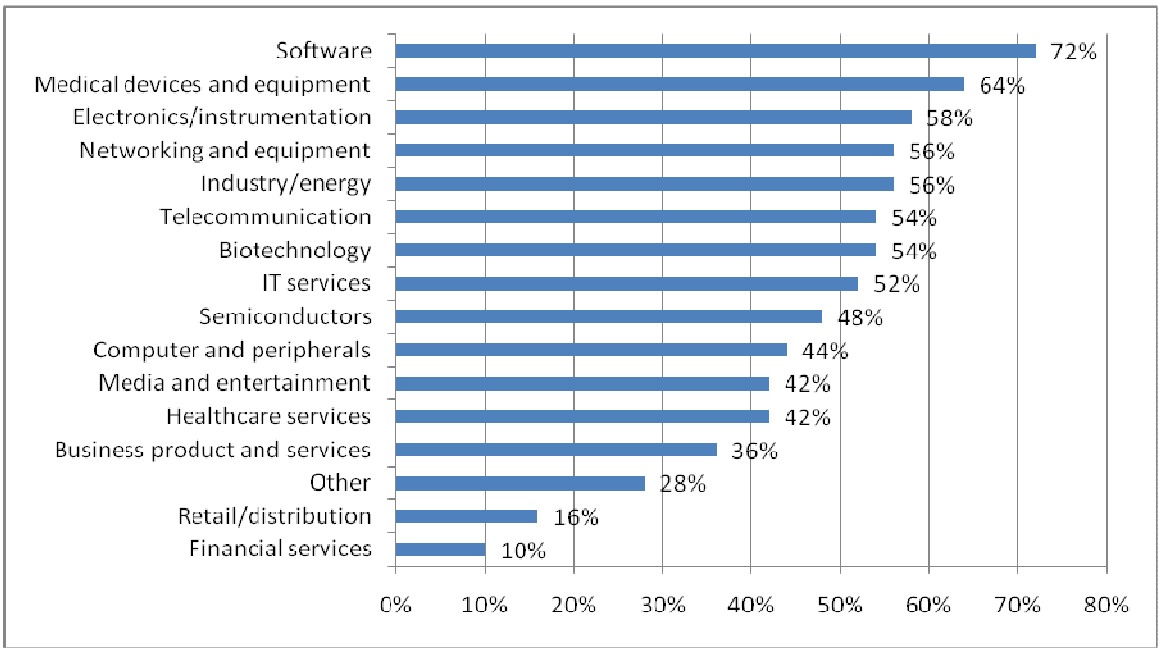


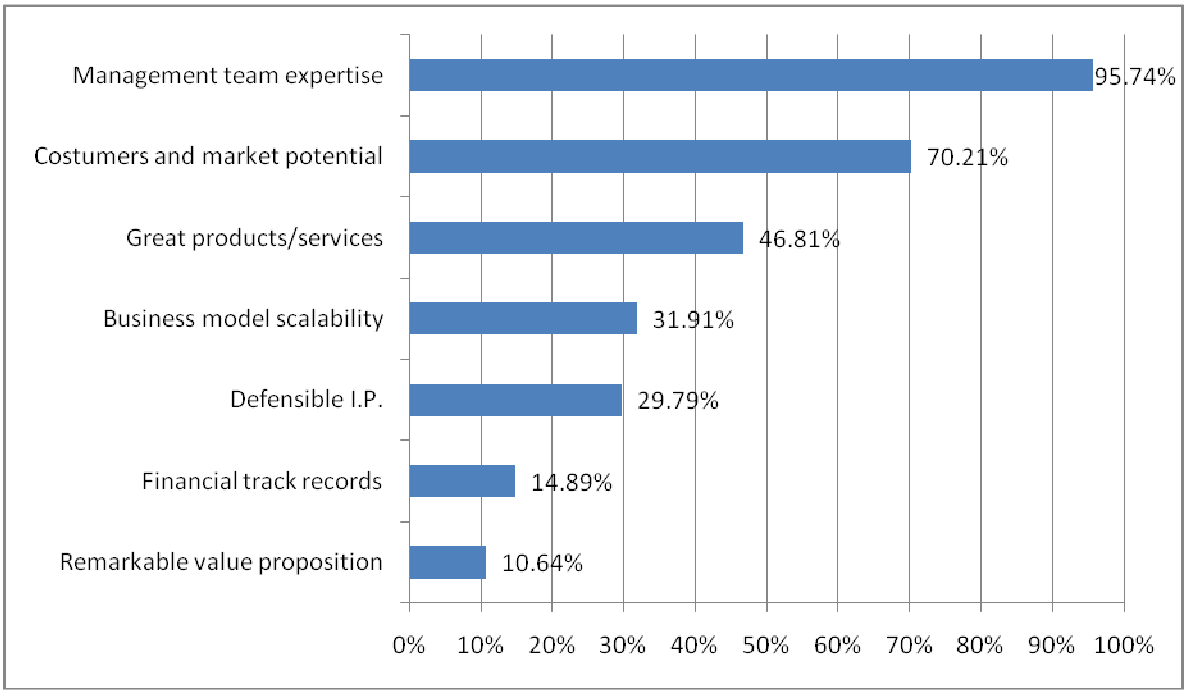
Table 38: Preferred industries

	All funds			Public funds			Co-investment funds			Private funds		
Variable	Obs	Mean	S. D.	Obs	Mean	S. D.	Obs	Mean	S. D.	Obs	Mean	S. D.
Biotechnology	50	0.54	0.50	26	0.65	0.49	16	0.38	0.50	8	0.38	0.52
Business product and services	50	0.36	0.48	26	0.46	0.51	16	0.25	0.45	8	0.13	0.35
Computer and peripherals	50	0.44	0.50	26	0.65	0.49	16	0.13	0.34	8	0.25	0.46
Electronics/instrumentation	50	0.58	0.50	26	0.81	0.40	16	0.38	0.50	8	0.13	0.35
Financial services	50	0.10	0.30	26	0.15	0.37	16	0.00	0.00	8	0.00	0.00
Healthcare services	50	0.42	0.50	26	0.58	0.50	16	0.19	0.40	8	0.38	0.52
Industry/energy	50	0.56	0.50	26	0.65	0.49	16	0.50	0.52	8	0.25	0.46
IT services	50	0.52	0.50	26	0.58	0.50	16	0.38	0.50	8	0.50	0.53
Media and entertainment	50	0.42	0.50	26	0.46	0.51	16	0.38	0.50	8	0.38	0.52
Medical devices and equipment	50	0.64	0.48	26	0.77	0.43	16	0.44	0.51	8	0.50	0.53
Networking and equipment	50	0.56	0.50	26	0.73	0.45	16	0.38	0.50	8	0.25	0.46
Retail/distribution	50	0.16	0.37	26	0.12	0.33	16	0.19	0.40	8	0.13	0.35
Semiconductors	50	0.48	0.50	26	0.62	0.50	16	0.31	0.48	8	0.25	0.46
Software	50	0.72	0.45	26	0.81	0.40	16	0.50	0.52	8	0.75	0.46
Telecommunication	50	0.54	0.50	26	0.77	0.43	16	0.38	0.50	8	0.13	0.35
Other	50	0.28	0.45	26	0.38	0.50	16	0.25	0.45	8	0.13	0.35
Industry specialisation	50	0.46	0.28	26	0.56	0.25	16	0.33	0.29	8	0.27	0.22

7.2.5 Investment criteria

Venture capitalists were asked to indicate the top 3 strengths of a business opportunity that normally motivates their investment. Their answers are illustrated in the graph below.

Figure 33: Investment criteria



The management team expertise is by far the most important strength of a business opportunity followed by the customers and market potential and great product or services. Financial track record and remarkable value proposition are the least important strenghts of a business proposal.

Table 39: Investment criteria

All funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Management team expertise	47	0.957	0.204	0	1
Business model scalability	47	0.319	0.471	0	1
Great products/services	47	0.468	0.504	0	1
Defensible I.P.	47	0.298	0.462	0	1
Costumers and market potential	47	0.702	0.462	0	1
Financial track records	47	0.149	0.36	0	1
Remarkable value proposition	47	0.106	0.312	0	1

Public funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Management team expertise	25	0.92	0.28	0	1
Business model scalability	25	0.28	0.46	0	1
Great products/services	25	0.52	0.51	0	1
Defensible I.P.	25	0.24	0.44	0	1
Costumers and market potential	25	0.76	0.44	0	1
Financial track records	25	0.16	0.37	0	1
Remarkable value proposition	25	0.12	0.33	0	1

Co-investment funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Management team expertise	14	1.00	0.00	1	1
Business model scalability	14	0.50	0.52	0	1
Great products/services	14	0.29	0.47	0	1
Defensible I.P.	14	0.43	0.51	0	1
Costumers and market potential	14	0.57	0.51	0	1
Financial track records	14	0.14	0.36	0	1
Remarkable value proposition	14	0.07	0.27	0	1

Private funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Management team expertise	8	1.00	0.00	1	1
Business model scalability	8	0.13	0.35	0	1
Great products/services	8	0.63	0.52	0	1
Defensible I.P.	8	0.25	0.46	0	1
Costumers and market potential	8	0.75	0.46	0	1
Financial track records	8	0.13	0.35	0	1
Remarkable value proposition	8	0.13	0.35	0	1

7.2.6 Personal characteristics of venture capitalists

Specific characteristics of venture capitalists may be used as predictions of their social behaviour. For example, time that the professional has spent within the company and the number of years that he or she lived in this particular region may be used as explanatory factors. The time within the company may allow professionals to develop their networks both within the venture capital community and among professionals in a range of external bodies. In the course of their investments, venture capitalists develop relationships with other VC firms and with experts and entrepreneurs in the industries in which they repeatedly invest and these networks provide privileged access to information about promising investments (Sorenson and Stuart 2001). Time within the region allows venture capitalists to acquire a deep knowledge of the region and to become widely known within the entrepreneurial community which perhaps will lead to greater business opportunities being brought to them. Hence, it is expected that prior knowledge of the investment firm and the region will increase the network of contacts within the region.

Table 40: Venture Capitalists personal characteristics

All funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Number of years in company	43	4.40	2.60	1	10
Number of years in the region	42	17.24	13.87	0	56
Advisor in a public organisation	46	0.22	0.42	0	1
Advisor in an private association or network	46	0.28	0.46	0	1

Public funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Number of years in company	25	4.16	2.44	1	9
Number of years in the region	24	13.63	11.86	0	50
Advisor in a public organisation	25	0.28	0.46	0	1
Advisor in an private association or network	25	0.20	0.41	0	1

Co-investment funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Number of years in company	13	4.85	2.30	2	9
Number of years in the region	13	22.92	14.71	4	56
Advisor in a public organisation	14	0.21	0.43	0	1
Advisor in an private association or network	14	0.43	0.51	0	1

Private funds

Variable	Obs	Mean	Std. Dev.	Min	Max
Number of years in company	5	4.40	4.28	1	10
Number of years in the region	5	19.80	17.95	3	50
Advisor in a public organisation	7	0.00	0.00	0	0
Advisor in an private association or network	7	0.29	0.49	0	1

On average, venture capitalists in the study sample worked in their current job and the same venture capital fund for 4.4 years, and live in the area for 17 years. This is an important indicator which allows to control for the affect of time within the company and the region and investigate whether time and experience is associated with the rate of interactions. The relatively high number of years living in the region may suggest a good knowledge of the regional entrepreneurial community and may also be an indicator of the age and seniority of the polled venture capitalists

The average number of years in the region varies between 14 years for public fund professionals to 23 years for co-investment funds professionals. The average number of years in the same company is similar to all examined type of funds, of between 4 and 5 years. As an indication of the venture capital professionals involvement in the community, venture capitalists were asked to indicate whether they hold any advisory role in a public organisation or private association. Twenty two percent of the venture capitalists are advisors to a public organisation but none of them works for a private fund. Ninenteen percent of the venture capitalists polled have been approached at some point in the past to accept such role but they rejected for one of the following reasons: "*Insufficient time and lack of focus in public body, I did accept it but have since resigned, Conflict of interest, waste of time, Conflict of interest, lack of time"* (survey responses). Twenty one percent of venture capitalist hold a position in a private association or organisation.

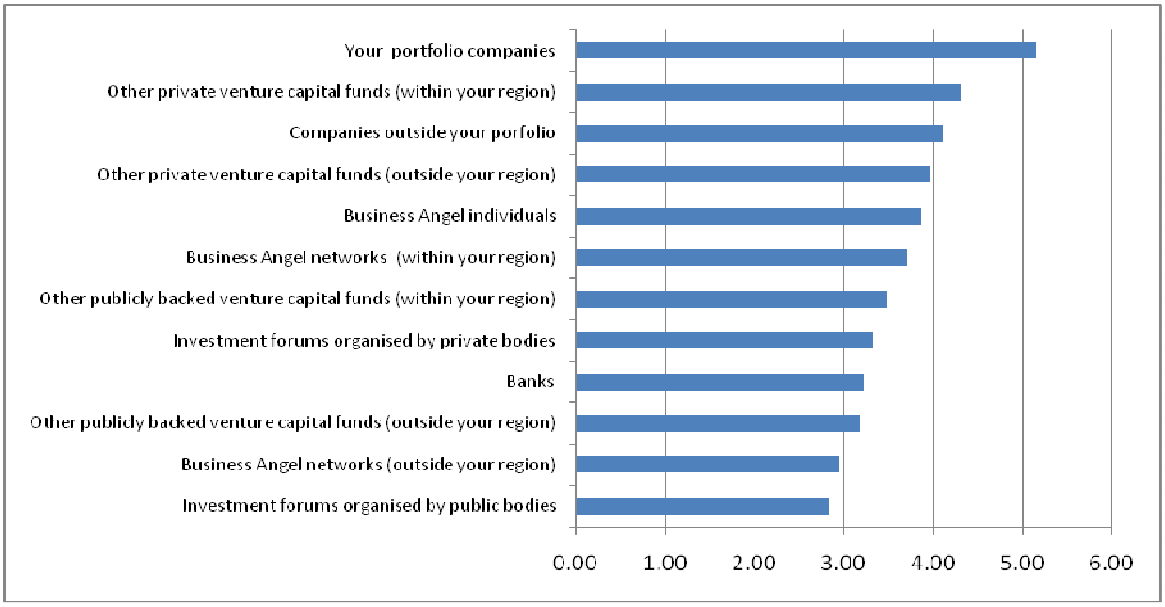
7.2.7 Rate of interaction

As stated earlier, this study aims to investigate the extent to which venture capital professionals interact with other bodies from the financial community and the outside world. Therefore two distinctive areas of examination have been identified: First, the internal VC community group, which consists of bodies such as portfolio companies, other venture capital funds, Business Angels networs, banks and investments forums. Second, the external VC community group, which includes

bodies such as universities, regional development agencies, public bodies, regional authorities, law companies, specialists, technology parks and incubators, networking event etc.

By making this separation between internal and external groups of contacts, it is possible to examine whether VC professionals interact with other professionals from finance community but not with the overall innovation community or vice versa. Venture capitalists were asked to state the extent of interaction with various bodies from the two groups, by choosing one of the following options: never, hardly ever - once a year at most, occasionally – a few times a year, regularly – once a month, often – more than once a month, very frequently – at least once a week. The results are illustrated below:

Figure 34: Internal interactions of the venture capital community (rating average)



(1= "never", 2= "hardly ever - once a year at most", 3= "occasionally – a few times a year", 4= "regularly – once a month", 5= "often – more than once a month", 6= "very frequently – at least once a week")

Table 41: Rate of interaction with the internal community

All funds

Variable	Obs	Mean	S.D.	Min	Max
Your portfolio companies	47	5.15	0.81	3	6
Companies outside your portfolio	45	4.11	1.42	1	6
Other private venture capital funds (within your region)	45	4.31	1.28	1	6
Other private venture capital funds (outside your region)	46	3.96	1.28	1	6
Other publicly backed venture capital funds (within your region)	44	3.48	1.13	1	6
Other publicly backed venture capital funds (outside your region)	44	3.18	1.19	1	6
Business Angel networks (within your region)	47	3.70	1.10	2	6
Business Angel networks (outside your region)	46	2.96	1.05	1	6
Business Angel individuals	45	3.87	1.27	2	6
Banks	45	3.22	1.40	1	6
Investment forums organised by private bodies	47	3.32	0.96	1	6
Investment forums organised by public bodies	47	2.83	0.89	0	5

Public funds

Variable	Obs	Mean	S.D.	Min	Max
Your portfolio companies	25	5.00	0.82	3	6
Companies outside your portfolio	24	4.00	1.44	1	6
Other private venture capital funds (within your region)	23	4.22	1.00	3	6
Other private venture capital funds (outside your region)	24	3.92	1.21	2	6
Other publicly backed venture capital funds (within your region)	23	3.91	0.90	2	6
Other publicly backed venture capital funds (outside your region)	23	3.57	1.12	2	6
Business Angel networks (within your region)	25	4.24	1.01	3	6
Business Angel networks (outside your region)	24	3.50	0.98	2	6
Business Angel individuals	23	4.22	1.20	2	6
Banks	23	3.26	1.42	1	6
Investment forums organised by private bodies	25	3.40	1.26	1	6
Investment forums organised by public bodies	25	3.04	1.02	0	5

Co-investment funds

Variable	Obs	Mean	S.D	Min	Max
Your portfolio companies	14	5.29	0.73	4	6
Companies outside your portfolio	14	4.14	1.41	2	6
Other private venture capital funds (within your region)	14	4.64	1.55	1	6
Other private venture capital funds (outside your region)	14	3.93	1.27	1	6
Other publicly backed venture capital funds (within your region)	14	3.00	1.24	1	5
Other publicly backed venture capital funds (outside your region)	13	2.69	0.85	1	4
Business Angel networks (within your region)	14	3.29	0.91	2	5
Business Angel networks (outside your region)	14	2.57	0.76	1	4
Business Angel individuals	14	3.43	1.22	2	6
Banks	14	3.57	1.34	1	6
Investment forums organised by private bodies	14	3.21	0.43	3	4
Investment forums organised by public bodies	14	2.64	0.63	1	3

Private funds

Variable	Obs	Mean	S.D.	Min	Max
Your portfolio companies	8	5.38	0.92	4	6
Companies outside your portfolio	7	4.43	1.51	2	6
Other private venture capital funds (within your region)	8	4.00	1.51	2	6
Other private venture capital funds (outside your region)	8	4.13	1.64	2	6
Other publicly backed venture capital funds (within your region)	7	3.00	1.15	2	5
Other publicly backed venture capital funds (outside your region)	8	2.88	1.55	1	5
Business Angel networks (within your region)	8	2.75	0.71	2	4
Business Angel networks (outside your region)	8	2.00	0.76	1	3
Business Angel individuals	8	3.63	1.41	2	6
Banks	8	2.50	1.31	1	5
Investment forums organised by private bodies	8	3.25	0.46	3	4
Investment forums organised by public bodies	8	2.50	0.76	1	3

Portfolio companies . As expected, there is an extremely high rate of interactions between the fund managers and their portfolio companies. On average, venture capitalists interact with their portfolio companies more than once a month, while a large percentage of them at least once a week. This interaction may include site visits, telephone calls, email exchanges or meeting. This finding is in line with Gorman and Sahlman (1989) argument that venture capitalists spend an average of four to five hours per month on site at each of the companies in which they play a lead role. In total, monitoring and advising occupies about half of the venture capitalist's time (Gorman and Sahlman 1989). Venture capitalists can offer more assistance to targets when they interact with startups' management frequently and in person (Sonerson and Stuart 2001).

Private venture capital funds. On average, venture capitalists interact with other private funds within their region on a regular basis (at least once a month) and they interact less with private funds outside their region. This suggests that geography is important when examining the rate of interaction of venture capitalists with private funds.

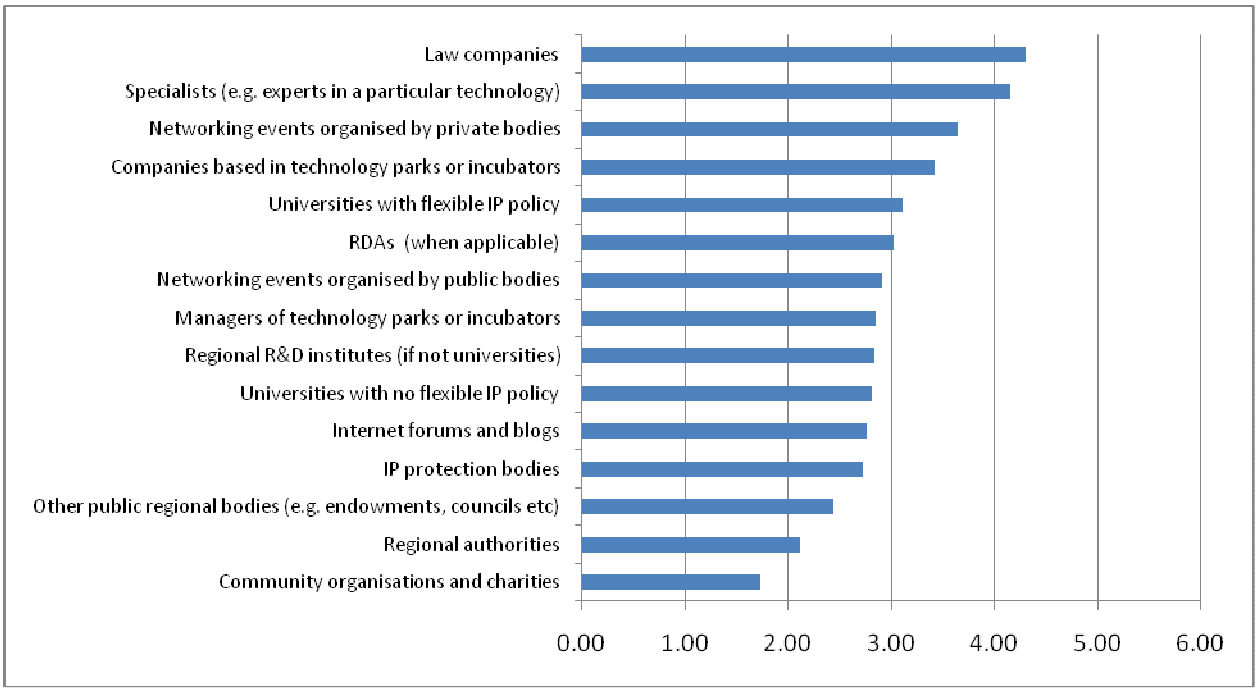
Business Angels. As shown in chapter 5, Business Angels have become a prominent source of early stage finance and their importance has been widely acknowledged in the recent years by various scholars (Mason and Harrison 2002b, 2008). The analysis shows that the majority of venture capitalists interact with Business Angel networks within their region and individual Business Angels at least a few times a month and many of them at least once a month. There is a significant lower rate of interaction with Business Angels network outside their region.

Investments forums. On average, venture capitalists participate in privately organised investments forums occasionally and at least few times a year but they attend similar events organised by public funds to a lesser extent.

Overall, the clear preference of venture capitalists to interact more with other professionals (venture capitalists from private and public funds and business angel networks) that have closer proximity is in line with the literature that suggests localised investment pattents (Sorenson and Stuart 2001).

Figure 35 analyses the rate of interaction between the VC community with what is traditionally considered as the regional innovation community. This community includes organisations and bodies such as Universities, regional development agencies, public bodies, regional authorities, law companies, specialists, IP protection bodies, technology parks and incubators and networking events. As previously, venture capitalists were asked to state the extent of interaction with all the above bodies.

Figure 35: External interactions of the venture capital community (rating average)



(1= "never", 2= "hardly ever - once a year at most", 3= "occasionally – a few times a year", 4= "regularly – once a month", 5= "often – more than once a month", 6= "very frequently – at least once a week")

Venture capitalists interact with law companies and specialists such as experts in a particular technology) on a regular basis and at least once a month. Networking events organised by private funds receive high attendance by venture capitalists. Networking events organised by public bodies are less well attended. Companies based in technology incubators are contacted occasionally – a few times a year – by venture capitalists. On average, the VC fund managers interact with Universities only occasionally - few times a year. The generally low rate of interaction between the VC community and the academia, regional R&D institutes and incubations suggests a common apathy for universities from the VC industry as a whole.

Table 42: External interactions

All funds

Variable	Obs	Mean	S.D	Min	Max
Universities with no flexible IP policy	47	2.81	1.04	1	6
Universities with flexible IP policy	47	3.11	1.07	1	6
Regional R&D institutes (if not universities)	47	2.83	1.31	1	6
RDAs (when applicable)	45	3.02	1.41	1	6
Other public regional bodies (e.g. endowments, councils etc)	44	2.43	1.13	1	6
Regional authorities	43	2.12	1.00	1	5
Law companies	47	4.30	1.16	2	6
Specialists (e.g. experts in a particular technology)	47	4.15	1.18	2	6
Community organisations and charities	44	1.73	0.79	1	4
Managers of technology parks or incubators	47	2.85	1.08	1	5
Companies based in technology parks or incubators	46	3.41	1.11	1	6
IP protection bodies	46	2.72	1.22	1	6
Networking events organised by private bodies	47	3.64	1.13	0	6
Networking events organised by public bodies	47	2.91	0.95	0	5
Internet forums and blogs	47	2.77	1.54	0	6

Public funds

Variable	Obs	Mean	S.D	Min	Max
Universities with no flexible IP policy	25	2.92	1.15	1	6
Universities with flexible IP policy	25	3.20	1.15	2	6
Regional R&D institutes (if not universities)	25	3.12	1.33	1	6
RDAs (when applicable)	25	3.28	1.34	1	6
Other public regional bodies (e.g. endowments, councils etc)	23	2.61	0.99	1	5
Regional authorities	22	2.23	0.97	1	5
Law companies	25	4.56	1.08	2	6
Specialists (e.g. experts in a particular technology)	25	4.52	1.08	2	6
Community organisations and charities	22	1.86	0.77	1	3
Managers of technology parks or incubators	25	3.28	0.89	2	5
Companies based in technology parks or incubators	25	3.76	1.09	1	6
IP protection bodies	24	2.96	1.37	1	6
Networking events organised by private bodies	25	3.64	1.32	0	6
Networking events organised by public bodies	25	3.20	1.08	0	5
Internet forums and blogs	25	2.36	1.44	0	6

Co-investment funds

Variable	Obs	Mean	S.D	Min	Max
Universities with no flexible IP policy	14	2.86	0.77	1	4
Universities with flexible IP policy	14	3.21	0.97	1	5
Regional R&D institutes (if not universities)	14	2.71	1.14	1	6
RDAs (when applicable)	12	3.08	1.16	2	5
Other public regional bodies (e.g. endowments, councils etc)	13	2.31	0.95	1	4
Regional authorities	13	2.15	0.99	1	4
Law companies	14	4.43	1.16	3	6
Specialists (e.g. experts in a particular technology)	14	3.93	0.92	2	5
Community organisations and charities	14	1.64	0.63	1	3
Managers of technology parks or incubators	14	2.57	0.65	1	3
Companies based in technology parks or incubators	13	3.08	0.49	2	4

Private funds

Variable	Obs	Mean	S.D	Min	Max
Universities with no flexible IP policy	8	2.38	1.06	1	4
Universities with flexible IP policy	8	2.63	0.92	1	4
Regional R&D institutes (if not universities)	8	2.13	1.36	1	4
RDAs (when applicable)	8	2.13	1.73	1	6
Other public regional bodies (e.g. endowments, councils etc)	8	2.13	1.73	1	6
Regional authorities	8	1.75	1.16	1	4
Law companies	8	3.25	0.89	2	4
Specialists (e.g. experts in a particular technology)	8	3.38	1.51	2	6
Community organisations and charities	8	1.50	1.07	1	4
Managers of technology parks or incubators	8	2.00	1.60	1	5
Companies based in technology parks or incubators	8	2.88	1.55	1	6

IP protection bodies	14	2.71	0.91	1	5
Networking events organised by private bodies	14	3.71	0.99	2	6
Networking events organised by public bodies	14	2.71	0.47	2	3
Internet forums and blogs	14	3.21	1.63	1	6

IP protection bodies	8	2.00	1.07	1	4
Networking events organised by private bodies	8	3.50	0.76	3	5
Networking events organised by public bodies	8	2.38	0.92	1	3
Internet forums and blogs	8	3.25	1.49	1	5

7.3 Limitations

One of the limitations of this study has been the relatively small sample size which is a result of the reluctance of venture capitalists to participate in academic studies. Several other limitations should also be kept in mind in interpreting the results of this study. First, because the data is based on self-reports, one must be cautious as regards their analysis and interpretation. Future studies may seek to supplement the self-reported measures used in this study with objective measures of interactions (such as number of emails exchanged, number of meetings attended, duration of telephone calls, and number of visits to the sites).

7.4 Are these differences robust?

The subsequent regression analysis examines the robustness of the findings controlling for several characteristics that may affect the rate of interaction between venture capitalists and several bodies. The rate of interaction between the venture capitalists and various bodies is regressed on a set of dummies for the type of venture capital funds (public or private) and control variables for size of fund, proportion of portfolio companies that generate revenue at the time of the investment (a proxy variable for risk), time that the venture capitalist has spent within the company and the region.

Table 43: Regression analysis, rate of interaction between VC and the internal finance community

1	*Your portfolio companies*	5	*Other publicly backed venture capital funds (within your region)*	9	*Business Angel individuals*
2	*Companies outside your portfolio*	6	*Other publicly backed venture capital funds (outside your region)*	10	*Banks*
3	*Other private venture capital funds (within your region)*	7	*Business Angel networks (within your region)*	11	*Investment forums organised by private bodies*
4	*Other private venture capital funds (outside your region)*	8	*Business Angel networks (outside your region)*	12	*Investment forums organised by public bodies*

Dep. var.(1-12)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Public funds	0.316	0.012	1.341	0.557	1.632	0.638	1.109	1.264	0.598	0.810	0.358	0.674
	(0.77)	(0.02)	(2.38)**	(0.82)	(3.48)***	(1.06)	(2.26)**	(2.49)**	(0.94)	(1.24)	(0.66)	(1.42)
Co-investment funds	0.347	0.227	1.688	0.547	0.245	-0.495	0.168	0.393	-0.003	0.576	-0.174	0.010
	(0.79)	(0.28)	(2.82)***	(0.76)	(0.50)	(0.77)	(0.32)	(0.74)	(0.00)	(0.85)	(0.30)	(0.02)
£11m-£30m	0.560	-0.247	0.878	0.145	-0.457	-0.793	0.181	-0.093	0.877	-0.371	-0.400	0.015
	(1.21)	(0.29)	(1.37)	(0.19)	(0.88)	(1.19)	(0.33)	(0.16)	(1.24)	(0.51)	(0.66)	(0.03)
£31m-£50m	0.695	0.415	1.350	0.524	1.301	0.582	0.256	0.336	-0.130	-0.130	0.195	-0.029
	(2.02)*	(0.61)	(2.83)***	(0.93)	(3.14)***	(1.09)	(0.62)	(0.75)	(0.23)	(0.23)	(0.43)	(0.07)
£51m-£151m	0.365	0.375	1.214	0.766	0.544	-0.097	-0.712	0.172	-0.523	-1.409	-0.279	0.019
	(1.11)	(0.62)	(2.61)**	(1.40)	(1.46)	(0.19)	(1.81)*	(0.43)	(1.03)	(2.72)**	(0.65)	(0.05)
Revenue	-0.008	-0.013	-0.020	-0.009	-0.016	-0.011	0.001	0.002	-0.004	0.008	-0.003	-0.011
	(1.77)*	(1.45)	(3.00)***	(1.16)	(2.97)***	(1.49)	(0.21)	(0.31)	(0.54)	(1.10)	(0.56)	(1.98)*
Years in region	0.019	-0.001	0.010	-0.012	0.030	-0.012	-0.012	-0.015	-0.025	0.011	0.019	0.015
	(1.71)*	(0.03)	(0.66)	(0.68)	(2.28)**	(0.64)	(0.93)	(1.04)	(1.40)	(0.64)	(1.30)	(1.20)
Years in company	0.044	-0.132	-0.012	-0.026	0.020	0.072	0.019	-0.002	0.063	0.184	-0.069	0.086
	(0.77)	(1.26)	(0.15)	(0.27)	(0.31)	(0.84)	(0.29)	(0.03)	(0.73)	(2.09)**	(0.93)	(1.32)
Constant	4.323	5.039	2.987	3.821	2.284	3.371	3.312	2.320	4.004	1.748	3.404	2.279
	(8.88)***	(5.55)***	(4.49)***	(4.79)***	(4.11)***	(4.58)***	(5.68)***	(3.86)***	(5.28)***	(2.27)**	(5.33)***	(4.05)***
Observations	40	39	38	39	38	37	40	39	38	38	40	40
R-squared	0.23	0.21	0.45	0.17	0.56	0.33	0.39	0.35	0.25	0.43	0.13	0.23

Absolute value of t statistics in parentheses

* significant at 10%, ** significant at 5%, *** significant at 1% ; private funds is the type of fund reference category; £1m-£10m is the reference size category

Table 43 column shows coefficients for the extent of interaction between venture capitalists and several bodies from the internal VC community, controlling for size of funds, proportion of portfolio companies generating revenues, years that the venture capitalists spent in the region and in the fund.

Column (1) shows that there is no statistically significant difference on the rate of interaction between the three examined type of funds (public, private and co-investment fund) and their portfolio companies. The size controls coefficients provide some indication that larger the fund is the more interactions it has with its portfolio companies. The variable ''revenue generation'' is a measure of the proportion of the portfolio companies that generate revenue. The coefficient for the variable revenue is negative and significant suggesting that the higher the proportion of portfolio companies generating revenue, the less the fund interacts with its portfolio companies. This is in line with the existing literature. Sapenza and Amason (1993) found that the rate of interaction between venture capitalists and entrepreneurs is very high at the early stages of finance and gradually is becoming less intense in the later stages. As they point out, apart from the money that is being put into the VC industry, the effectiveness of communication is often crucial to the realization of technological advances. Finally, the coefficient for the variable 'years in the region' is also positive and significant suggesting that the longer a venture capitalist spends in the regions the more often he or she interacts with the portfolio companies.

Companies outside portfolio (column 2). Venture capitalists interact at least once a month with portfolio companies outside their portfolio. These companies will most likely be companies seeking to raise finance from the funds. In this case, there is no significant difference in the extent of interaction between these companies and the type of funds.

Private venture capital funds (columns 3 & 4). On average, publicly backed venture capitalists and co-investment funds interact significant more often with private VC funds from their regions compared with their private counterparts and the coefficient is high and statistically significant. The size controls indicate that larger funds interact more often with private VC funds form the region compared with smaller funds. The coefficient for the variable revenue is again negative and significant. The coefficients for the dependent variable ''other private funds outside your region'' are not significant, suggesting that there is no difference on the extent of interaction between any type of funds and private funds that are not based in the same region.

Public venture capital funds (columns 5 & 6). A very similar picture emerges when looking at the extent of interaction with other public funds. Public funds interact with public funds from the same

region to a much higher extent than private or co-investment funds do. Funds with assets between £31m-£50m interact with public funds from the same region to a much larger extent than smaller or larger funds. The coefficients for the variables revenue and years in the region continue to be statistically significant. The coefficients suggests that public funds interact more with other public funds than private funds, while there is no difference in the rate of interaction between public and co-investment funds. Public funds employees interact with each other at a higher rate within their region. Based on the interviews with the VC managers, "*this is possibly due to the fact that publicly backed fund managers have developed closer relationships with the counterparts from the public rather than the private sector"* (interviewed venture capital manager). There are no differences in the extent of interaction between public funds outside the region and any type of venture capital funds.

Business Angels (columns 7 & 8) suggest that there is a considerable difference between the rates of interactions between the Business Angel networks (inside or outside the region) and the different types of venture capital funds. Public funds interact with BAs networks over twice as many times as their private counterparts. A venture capitalist that works in a publicly backed fund is twice as likely to interact with a business angel than a venture capitalist from the private sector. Professionals from funds with size between £51m - £151m interact with BAs networks from the region less often than smaller funds. The strong and positive relationship between public funds and Business Angels is also reflected in the source of deals that was examined earlier in this chapter. There is no significant difference between the extent of interaction between individual Business Angels and different type of funds. As expected, large funds are less likely to interact with Business Angels than smaller funds. The time that a venture capitalists spent in the company is positive and significantly associated with the extent of interaction between individual Business Angels and professionals, indicating the importance of personal relationships in the sector.

Investments forums (column 10 & 11). There are no significant differences on the rate of participation in investment forums between different types of venture capitalists.

Overall, there is a clear pattern of the ecology of interaction between different types of venture capitalists and the internal community. First, professionals from public funds interact more often with professionals from the same region compared with their private counterparts. Second, public funds interact significantly more often with Business Angel networks than private funds do. Third, medium size funds (£31m-£50m) seem to be more active than smaller or larger funds in interacting with the internal community. Forth, the less revenue the portfolio companies generate, the more

active the venture capitalists are; and finally, there are some indications that the more time a venture capitalist spent in the region the more he or she interacts with bodies from the same region.

Table 44: Regression analysis, rate of interaction between VC and the innovation community

1	*Universities with no flexible IP policy*	6	*Regional authorities*	11	*Companies based in technology parks or incubators*
2	*Universities with flexible IP policy*	7	*Law companies*	12	*IP protection bodies*
3	*Regional R&D institutes (if not universities)*	8	*Specialists (e.g. experts in a particular technology)*	13	*Networking events organised by private bodies*
4	*RDAs (when applicable)*	9	*Community organisations and charities*	14	*Networking events organised by public bodies*
5	*Other public regional bodies (e.g. endowments, councils etc)*	10	*Managers of technology parks or incubators*		

Dep var Public funds	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Public funds	0.967	1.052	1.590	1.114	0.086	0.115	1.767	1.157	0.634	1.288	0.767	1.525	0.662	0.787	-0.410
	(1.75)*	(1.88)*	(2.66)**	(1.83)*	(0.15)	(0.21)	(3.09)***	(2.01)*	(1.68)	(2.61)**	(1.55)	(2.50)**	(1.12)	(1.66)	(0.52)
Co-investment funds	0.763	0.930	0.882	0.751	-0.188	0.239	1.277	0.521	0.443	0.439	0.033	1.006	0.482	0.082	0.618
	(1.30)	(1.56)	(1.38)	(1.13)	(0.31)	(0.42)	(2.09)**	(0.85)	(1.13)	(0.83)	(0.06)	(1.55)	(0.77)	(0.16)	(0.73)
£11m-£30m	-0.157	0.249	0.779	-0.320	0.357	0.305	1.003	0.352	-0.808	0.299	-0.392	0.044	-1.148	-0.343	-0.747
	(0.24)	(0.37)	(1.08)	(0.44)	(0.51)	(0.46)	(1.46)	(0.51)	(1.78)*	(0.50)	(0.66)	(0.06)	(1.62)	(0.60)	(0.78)
£31m-£50m	-0.186	-0.225	0.167	-0.730	0.478	0.715	-0.012	0.379	-0.386	0.052	-0.080	-0.370	-0.687	-0.288	0.649
	(0.29)	(0.34)	(0.24)	(1.03)	(0.72)	(1.15)	(0.02)	(0.56)	(0.90)	(0.09)	(0.14)	(0.52)	(0.99)	(0.52)	(0.70)
£51m-£151m	-0.342	-0.373	0.369	-0.488	0.745	0.832	0.613	0.366	-0.310	0.295	-0.187	0.276	-0.134	-0.149	-0.263
	(0.55)	(0.59)	(0.55)	(0.71)	(1.16)	(1.38)	(0.95)	(0.56)	(0.74)	(0.53)	(0.33)	(0.40)	(0.20)	(0.28)	(0.29)
Revenue	-0.016	-0.015	-0.025	-0.022	-0.013	0.003	0.003	-0.014	-0.002	-0.007	-0.012	-0.010	-0.009	-0.013	0.006
	(2.48)**	(2.30)**	(3.65)***	(2.99)***	(1.93)*	(0.50)	(0.38)	(2.11)**	(0.35)	(1.28)	(2.03)*	(1.39)	(1.35)	(2.28)**	(0.67)
Years in region	-0.001	-0.004	0.008	-0.006	-0.021	-0.031	0.016	-0.008	-0.008	-0.004	-0.011	0.005	0.015	0.009	-0.005
	(0.06)	(0.24)	(0.51)	(0.35)	(1.23)	(1.93)*	(1.09)	(0.53)	(0.79)	(0.30)	(0.81)	(0.33)	(0.93)	(0.75)	(0.25)
Years in company	0.149	0.166	0.102	0.377	0.202	0.129	-0.004	0.006	0.098	0.144	0.073	0.060	0.034	0.120	-0.211
	(1.97)*	(2.16)**	(1.24)	(4.29)***	(2.54)**	(1.73)*	(0.05)	(0.08)	(1.90)*	(2.12)**	(1.08)	(0.71)	(0.42)	(1.85)*	(1.94)*
Constant	2.261	2.349	1.736	2.027	1.949	1.218	2.090	3.704	1.363	1.547	3.623	1.645	3.600	2.512	3.570
	(2.93)***	(3.00)***	(2.07)**	(2.38)**	(2.42)**	(1.61)	(2.61)**	(4.60)***	(2.62)**	(2.23)**	(5.22)***	(1.92)*	(4.35)***	(3.78)***	(3.22)***
Observations	40	40	40	38	37	36	40	40	37	40	39	39	40	40	40
R-squared	0.24	0.26	0.42	0.46	0.31	0.25	0.34	0.30	0.29	0.34	0.30	0.27	0.25	0.29	0.23

Absolute value of t statistics in parentheses

* significant at 10%, ** significant at 5%, *** significant at 1%; private funds is the type of fund reference category; £1m-£10m is the reference size category

Universities (Columns 1 & 2). The coefficients for public funds and universities (with or without flexible IPs) are both positive and significant suggesting that public venture capital funds interact more often with universities than the private venture capitalists do. In addition, the variable revenue is negative and statistically significant suggesting that funds which are more interested in companies that do not generate revenue are more likely to interact with universities. The time that a venture capitalist has spent in the fund is positive and significant associated with the extent of interaction with universities, perhaps suggesting that it takes time for a professional to establish contacts with the universities. Alternatively, and more likely, the positive coefficient of this variable, which is often positive and significant for several regressions in the table, may indicate that the people that have established these relationships are professionals that spent many years in the public sector and therefore are better connected with other public organisations.

Regional R&D institutes (column 3). There is a significant difference between the rate of interactions between different type of venture capitalists i.e. venture capitalists from the public sector interact with R&D institutes more than twice as much that professionals from the private sector. The results also strongly suggest that the more revenue the portfolio companies generate, the less interaction the fund has with the regional R&D institutes.

Regional development agencies (column 4). A similar picture emerges when looking at the extent of interaction with regional development agencies. Publicly backed venture capitalists interact much more often with RDAs than their private counterparts. This is not surprising as many of these funds have been set up by RDAs.

Other public regional bodies (columns 5 & 6). Venture capitalists of any type have not established strong links with other public regional bodies or regional authorities, and those that they had, have spent several years in the same company.

Law companies, Specialists and IP protection bodies (columns 7, 8 & 12). There is strong evidence that venture capitalists working for publicly backed funds or co-investment funds interact with law companies, specialists and IP protection bodies much more often than their counterparts from the private sector. There is also evidence that the size of funds determines the rate of interaction as indicating that very small funds are less likely to interact with law companies, specialists or IP protection bodies. The positive coefficient between public funds and law companies may be explained by "*the way the fund managers are rewarded under the public funds as opposed to private funds. In other words, it would be worth exploring whether private fund managers have more of an incentive to minimise costs by suppressing legal fees (perhaps foolishly in the long run!). Along the*

same thinking, public funds may suffer from the fact that it is always easier to spend someone else's money rather than one's own", as a professional from a law company has commented (interview). In addition, public funds may interact more often with specialists than private funds due to their *"lack of skills, expertise, and inability to recruit specialised people in house"* (interview).

Technology parks and incubators (columns 10 & 11). The high and positive coefficient between the public venture capitalists and the managers of incubators demonstrates that venture capitalists working for a publicly backed fund are substantially more likely to interact with incubator managers than their private counterparts. On average, private venture capitalists interact with the managers of technology parks or incubators hardly ever and once a year at most. This is an interesting finding which suggests that by and large, business incubators have not succeeded in attracting the interest of private venture capitalists.

7.5 Ecology of interactions within the Welsh VC community

Figure 36 visually compares the rate of interaction between the venture capitalists and other players of the financial community in Wales with the average rate of interaction of all UK regions. It suggests that there are several differences in the way that the Welsh and other VC communities interact with the rest of the internal finance community. More particularly, professionals from other regions, based on both private fund and other publicly backed funds, interact with companies (inside or outside their portfolio) much more often than their counterparts from Wales. Similarly, they interact more often with other funds (private or public), inside and outside the region than the Wales based venture capitalists. Interestingly, Wales based VC funds have much more active interactions with banks than all other regions, mainly reflecting the fact that FW is also operating several loan funds that require close collaboration with banks.

Figure 36: Ecology of interactions in Wales (internal finance community)

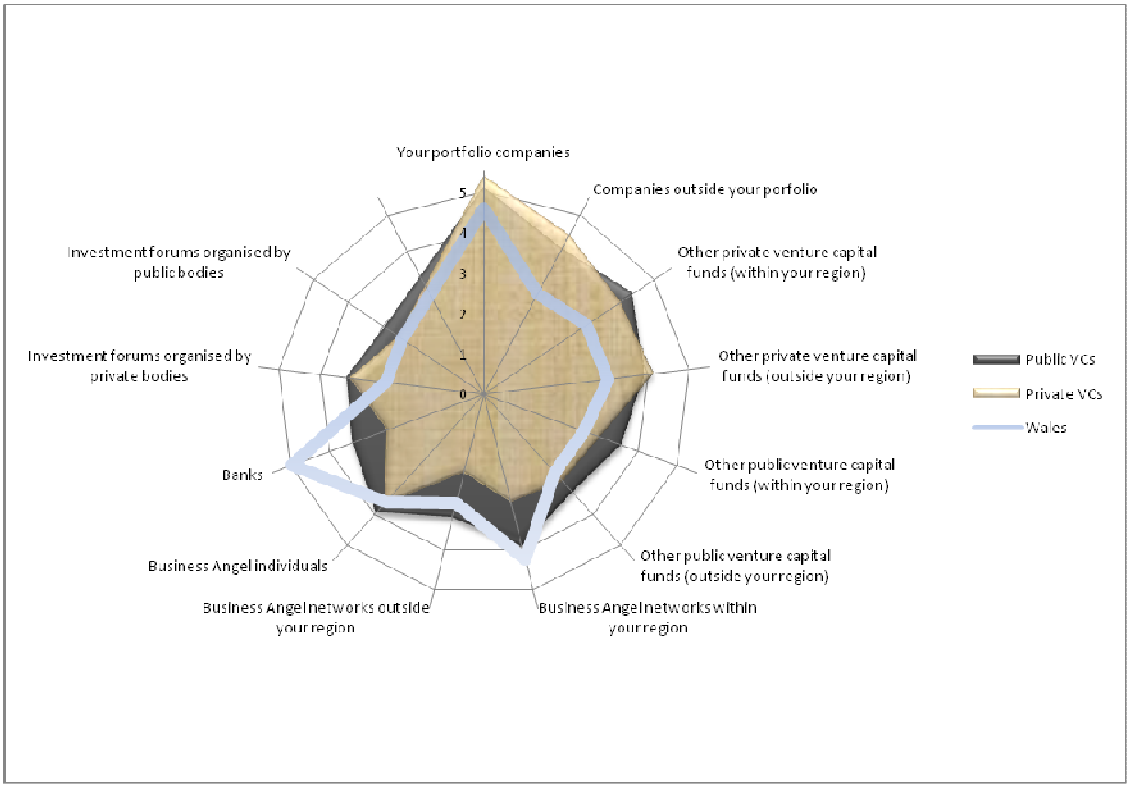
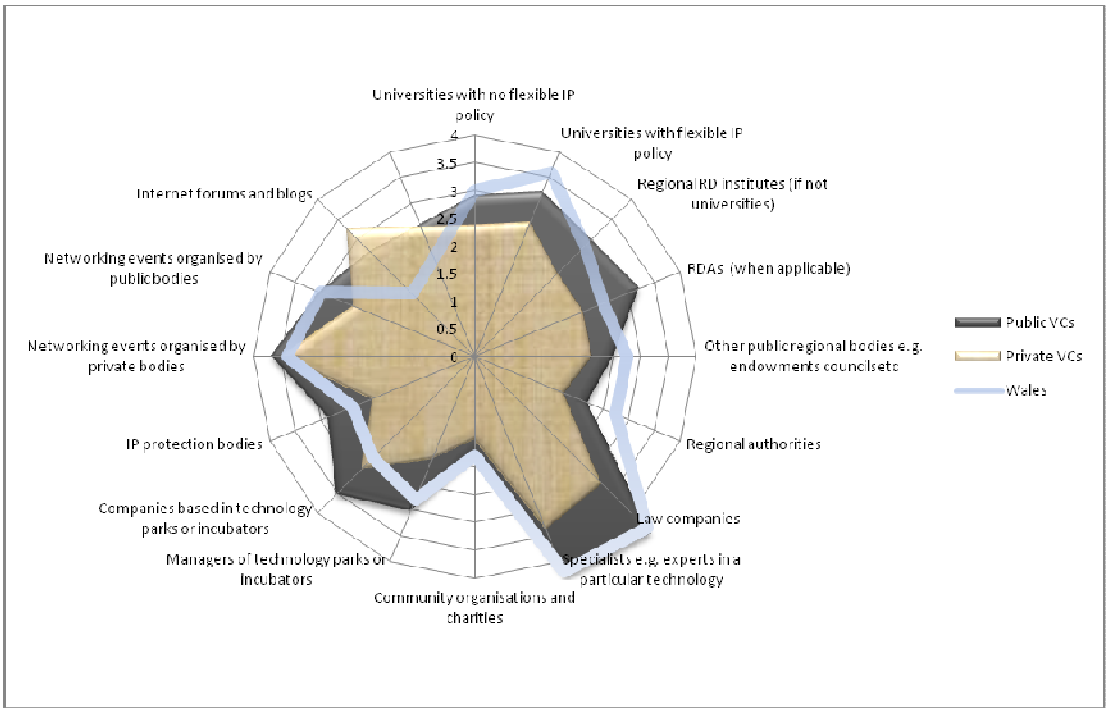


Figure 36 indicates that Welsh venture capital professionals interact significantly less with several bodies of the finance community compared with their counterparts from both the public and the private sector (companies outside their portfolio, other private venture capital funds inside or outside Wales and other public venture capital funds within Wales). Their rate of interaction with Business Angels is in line with public venture capital VCs on average but show a significanly higher interaction with banks.

Figure 37: Ecology of interaction in Wales (innovation system)



The ecology of interactions amongst venture capitalists and other players of the regional innovation system in Wales, shares similar characteristics with the ecology of interaction of the average publicly backed UK region. Figure 37 also suggests above average rate of interactions with the Universities with flexible IP policy (perhaps due to Cardiff University and its relationship with Biofusion) but below average rate of interactions with companies based in technology parks and incubators. Finally, venture capitalists based in Wales do not make use of the internet to the same extent as their counterparts from other regions, regardless of the type of funds.

7.6 Conclusions

This chapter analysed the rate of interaction between venture capitalists and other players of the innovation system and presented clear evidence that the volume of interaction is strongly associated with the nature of the fund. Two important findings emerged from this analysis.

First, public dependence is strongly and significantly associated with higher volumes of interactions. The more publicly dependent a fund is, the more it interacts with other players. This suggests that publicly backed venture capitalists have the capacity to activate the search and screening process over a wide network of contacts within a geographical space and can deploy the extensive reach of their networks to identify and evaluate investments opportunities.

Second, the results also show that operators of publicly backed funds are lacking close connections with their counterparts from the private sectors. This may have implications for their ability to approach and attract private heavy weighted venture capital funds and LPs that can provide follow on investments or raise further funding for the fund.

This reinforces previous findings from this thesis, suggesting that there are currenlty two distincitve venture capital communities in the UK: one which is privately led and includes London, the South East and the East of Engalnd, and one which is publicly led and includes all the remaining regions.

Although the findings from this analysis cannot be generalised for the whole venture capital industry, they provides significant insights for the UK early stage technology focused venture capital industry. There are some common characteristics in the way that the two communities operate, and also some distinctive differences.

Common characteristics

In line with the findings from chapter 5, the majority of the venture capital funds deals are co-investments. The extent to which the venture capitalists co-invest with other finance bodies varies significantly. Almost all of the venture capitalist polled co-invest with private funds to some extent. However, the extent of public dependency of the fund is highly associated with the proportion of co-investment deals. In other words, the more public finance a fund has the more it co-invests with other funds. This is of course oblibagory in most cases due to state aid legislation.

Personal business contact is the main source of deals for all type of funds, followed closely by the entrepreneur's direct approach to the investment fund.

The majority of the venture capitalists invest in companies that do not generate sales revenue at the time of initial investments.

The most prefered industry for investments is software. The second most preferred industry is medical devices and equipment followed closely by electronics/instrumentation and industry/energy. Financial services and retail/distribution are the least preferred sectors of investments.

The management team expertise is by far the most important strenght of a business opportunity followed by the costumers and market potential and great product or services. This is in line with previous research that found that good management is by far the most important attribute in making a company attractive to potential VC investors (more important even than the initial product or service proposition), as VCs consider it is this which will help ensure good returns (SQW 2009).

Financial track record and remarkable value proposition are the least to important strenghts of a business proposal. There is no evidence to suggest that publicly backed fund managers have different criteria when investing.

Differences

All panels show that venture capitalists employed by a publicly backed fund interact with the other bodies more often than the private venture capitalists do, and are more engaged with the innovation community. The extent of public dependency significantly affects the extent of interaction, the more public money under management, the more engaged the fund is with the regional community.

Publicly backed venture capital professionals interact with public funds within their region substantially more than their private counterparts. More particularly, private venture capitalists interact twice as much with their private counterparts than the publicly backed ones.

Publicly backed fund professionals interact with Business Angel networks within or outside their region to a much greater extent than their counterparts from the private sector. Business Angels networks are much more connected with the publicly backed rather with the private funds.

As a general observation, all venture capitalists do not interact to a great extent with their external community. However, the differences in the extent of interaction between different types of venture capitals and players of the external community are quite substantial suggesting that public venture capitalists are responsible for the vast majority of interaction that takes place between the VC and the innovation community.

Publicly backed venture capitalists interact twice as much with regional R&D institutes, RDAs, law companies, specialists, managers of technology parks, companies based in technology parks, IP protection bodies and networking events organised by public bodies compared with their counterparts from the private sector. This suggests that:

First, professionals from the publicly backed funds have the – sometime implied – objective to interact with other players of the regional innovation system in order to foster the entrepreneurial and innovation community. In order to meet these objectives, such professionals have established links with the above bodies.

Second, public organisations such as RDA, technology parks and incubators did not manage to attract the interest of the private VC funds. This is open to two interpretations. First, either the professionals of these bodies are not active enough in the area and have not made the private VC

funds aware of their pool of opportunities, or second, these organisations do not contain a pool of business proposals that the private venture capitalist would be interested in investing.

Public funds are mainly responsible for most of the interaction that is taking place between the Business Angel networks and the formal VC community. This is an important finding that policy makers need to take into consideration given the fact that BAs are emerging as prominent players in the early stage risk finance community. This relationship is also reflected in the source of deals.

Although it is widely acknowledged that interactions between venture capitalists and other players promote tacit knowledge (Zook 2004), the results of this study suggest that interaction on its own is not enough to provoke success. Publicly backed venture capitalists interact with the internal and the external to the VC community organisations to a greater extent than their private counterparts, but they experience less success, measured by the financial performance of the funds (NAO 2009) or business performance of their portfolio companies (NESTA and BVCA 2009). In addition, when they invest alone they are less likely to invest in companies with the potential to innovate compared with private funds. In other words, the rate of interaction between venture capitalists and other professionals is not correlated with greater success and the funds that interact more, are less successful that funds that interact less. *Why may this be happening?*

First, it is important to note that publicly backed funds are a relatively new concept. The systems and stores of tacit knowledge used by venture capitalists do not emerge overnight and a simple supply of money is not the same as a well-developed venture capital system (Zook 2004). The structure of social and professional relations is likely to influence which actors in the VC business become aware of promising, early stage investments opportunities, and timely information regarding high-quality investment opportunities often reaches a venture capitalist through his network (Sorenson and Stuart 2001). Publicly backed fund professionals therefore are dependent not only on their personal capacity to mobilise their network of contact but also on how reliable information the members of the network can exchange. Venture capitalists with deep contact networks in an industry or a geographic area can often better assess the veracity of the information they receive about the quality of an investments opportunity (Sorenson and Stuart 2001) which means that public VC professionals may not have this deepness required.

Second, higher rate of interaction does not necessary mean that venture capitalists become aware of better opportunities that those who interact less. As Fried and Hisrich (1994) put it, weakly affiliated actors may lack the incentive to refer only high quality investments (Fried and Hisrich

1994), and therefore private venture capitalists compensate by relying more heavily on their personal ability to access quality differences among business opportunities.

However, when public funds co-invest with private funds, they are more likely to invest in companies with the potential to innovate compared with those that private funds invest in. The co-investment model seems to be the most effective model of VC investing especially for regions with high dependency on public sector. However, publicly backed funds based in highly publicly depended regions may experience difficulties in identifying private sector investment partners and as a result, these regions are likely to experience low rate of co-investment activities and consequently high rates of solely public deals. As a result there is a danger of a vicious circle where public VC funds of some regions will continue to underperform private funds - making it hard to raise more funds; their portfolio companies will continue to benefit very little from the investments; and they will continue to support relatively fewer companies with the potential to innovate compared with private funds.

The findings of this chapter suggest that the mobilisation of the innovation network within the regions is not enough on its own to boost innovation performance of the VC backed companies. Just networking and exchanging information between innovation bodies and financial bodies is not adequate. The existence of private funds in the region is crucial in order to bring the skills and characteristics that public funds lack. Alternatively, public funds in publicly dominated regions should be encouraged to attract private investments from outside investors. They could be seen as the pipeline of valuable information about investable opportunities in peripheral regions to London and South East based private VC funds.

As discussed earlier, co-investment activity is a learning process for the public funds and eventually professionals from the public funds will acquire the same skills as their private counterparts. However, this assumes that these funds and schemes are sustainable in the long term, invest into human capital and appropriately incentivise their personnel. Small funds, with a short life span are not likely to create this environment in the public sector dominated UK regions.

8 CHAPTER 8 : CONCLUSIONS

8.1 Introduction

Since the beginning of the century, a variety of venture capital schemes were introduced in the UK. These schemes established several publicly backed funds that have become important players in the regional financial and innovation systems. The main sources of public funding for such funds have been the European Union and Government departments or devolved administrations, followed by RDAs, universities and regional authorities.

An important objective of the publicly backed funds has been to attract funds from private investors and develop a vibrant private venture capital market in each UK region. The evidence from the UK regions suggest that this has not happened at least at the early stage VC market, as the majority of the regions are currently dominated by publicly backed funds. Outside London, Cambridge and the South East, public sector VC investments vastly outweigh private sector ones. This longer trend of private venture capital funds exiting from the early stage market could not be stopped by the establishment of publicly backed regional funds. This trend may be a result of several reasons: since the dotcom crash, the early stage venture capital industry has been generating poor returns; there may be a lack of early stage investable opportunities in several regions. Alternative, there is a problem of 'thin markets' where limited numbers of investors and entrepreneurial growth firms within the economy have difficulty finding and contracting with each other at reasonable costs (NESTA 2009).

This thesis sought to map and measure the extent of public involvement in the UK VC market and to access the potential implications of such involvement in the companies and regions. More particularly, as outlined in chapter one, this research was concerned with the following questions:

1. Has the supply of private sector venture capital and supportive public interventions changed the availability of venture capital at the regional level?

2. Is a higher volume of VC investments positively correlated with higher volume of patent applications?

3. Are public funds less effective in investing in companies with the potential to innovate, than private funds?

4. What is the ecology of interaction between venture capital and regional innovation systems, how does this differ spatially and why, and how does the venture capital community fit within the regional innovation system?

8.2 Theoretical and empirical contributions to broader academic debates

8.2.1 Theoretical contributions

The literature review reveals the importance of context when exploring the link between innovation finance and regional development. Innovation finance is a critical resource in the development and growth of many new firms. To date, few studies have attempted to understand the role of finance within the regional innovation system. In part this can be explained by the relatively newly established literature on regional innovation and the complexity of the financial mechanisms that favour innovation creation. 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 (Dee and Minshall 2011). Nonetheless the literature indicates several features of innovation financing, especially venture capital investments, that may affect the regional innovation system which this thesis has explored further with the support of qualitative and quantitative data. This thesis contributes to the literature of regional development, regional innovation and venture capital in several ways.

Economic geography theories

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). While the linear model has theoretical elegance, the majority of studies suggest more dynamic and complex processes involved in innovation and industrial emergence (Dee and Minshall 2011). This is also the case for venture capital. Venture capital activity does not support the linear approaches to innovation i.e. investment into a company will simply increase R&D expenditure and therefore promote innovation. A common perception in the literature is that venture capital investment is a complex process that involves

extensive and multiple interactions, tacit knowledge and networks, and in that sense it fits well with the evolutionary theories of innovation. According to Cooke et al. (1997):

"the evolutionary approach is well-suited to the analysis of innovation practices because of its emphasis upon process, learning and cooperative, as well as competitive, dimensions of interfirm relations. This contrasts with the static equilibrium, arm's length exchange and atomistic utility-maximisation assumptions of the neoclassical economics perspective" (Cooke et al. 1997, p.476).

A major concern is the ability to direct financial resources towards those activities most likely to contribute to the development of an entrepreneurial culture within the regional innovation system. The entrepreneurial financing industry continues to release reports arguing for linear approaches: 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 (Dee and Minshall 2011). This requires a more complete perspective of entrepreneurial activity rather than reliance on a linear innovation process where funding gaps are identified and filled. The literature, for example, suggests entrepreneurial ventures may experience greater difficulty accessing required finance when they are at the early stage of development. Whilst a decline in the availability of entrepreneurial financing may occur, they do not necessarily reflect a decline in the financing needs of investable firms (Dee and Minshall 2011). Instead the supply of entrepreneurial finance seems predominantly driven by other factors in the business environment, such as the confidence in public markets (Dee and Minshall 2011) or the environment in which the firms operate (NESTA 2011).

The evolutionary economics approach can better conceptualise the units of co-operation that interact within the venture capital operational frameworks and explain its dynamics. As seen in the findings of this research, successful venture capital communities cannot be generated in a pre-given order, but instead they are created through a complex puzzle of quality interactions and networks. These networks of associations generate the dynamics that add value to the pre and post investment processes. These dynamics can be better function within an effective innovation system which facilitates the generation, diffusion and absorption of new knowledge and it has the appropriate mechanisms in place to commercialise such knowledge.

This thesis therefore suggests that effective venture capital activity is based on theoretical insights found in institutional and evolutionary economic theories such as locally embedded knowledge, social and cultural characteristics and the importance of proximity as a source of knowledge and learning. More particularly, venture capital supports the main attributes of the evolutionary theories and those of innovation systems in several respects by promoting knowledge transfer, tacit

knowledge, learning, networking and associated spill over effects. It co-habits with innovative firms and promotes clustering spill over effects.

Regional development

The geography of venture capital investments in the UK continues to be characterized by regional Inequalities as previous studies have indicated (Mason 1987, 2007; Mason and Harrison 1991, 2002; Martin 1989, 1992 and Martin et al. 2005). As shown in chapter 5, investment activity in the UK is regionally concentrated in London and the South East followed by the East of England. In these three regions, and especially London, there is an easy access of venture capital firms to the pools of knowledge and expertise and therefore funds based in these three regions are more likely to invest locally (Martin et al. 2001). This is also based on the evidence in the literature which suggest that personal contact and face to face meetings is of great importance in venture capital investing. As shown in chapter 5, the relative growth of venture capital activity in the Midlands and North England is an outcome of the increased supply of public venture capital funds.

The findings of this research affirm the findings from previous analyses showing that there are only few regional concentrations of venture capital investments in the UK. The role of venture capital in clusters development is evident (see Porter 1998, 2000) but there is an absence of strong clusters in the UK – apart from the South East and a much smaller cluster in Cambridge (Martin et al 2001). Following on from the "clustering versus dispersal" debate (see Martin et al. 2001), on the one hand, venture capital can be more effective if concentrated in clusters of high-technology companies, and as it is evident in chapter 5 the current market supports the concentration of venture capital activities in specific agglomerations. One the other hand, there is increasing need for peripheral regions to have access to early stage funding which is necessary for the development of entrepreneurial activity and thus reducing regional inequalities. Clearly, meeting these apparently opposing imperatives poses a real challenge, as it implies that both core and peripheral regions will need to develop their own specialised venture capital agglomerations (Martin et al. 2001).

The finding of this thesis suggest that venture capital investments will continue to be clustered around these three areas and any attempt to artificially disperse the venture capital activity around the country will not be successful unless it is followed by a "dispersion of the demand for venture capital investments". It should not be expected that the supply of venture capital will automatically create its own high-tech-based demand. Therefore, policies to create or stimulate regional venture capital funds and investment activity need to be combined with other measures aimed at fostering

and supporting regional clusters of high-technology research, innovation, and small firm start-ups (Martin et al. 2001, p.27)

Innovation policy

The literature also highlights the important role of venture capital in regional innovation. This thesis contributes to this literature further but highlights some of its limitations. First, although innovation policy approaches tend to support the value of interactions between different players of the regional innovation system, the findings of this thesis suggest that interaction on each on it is not enough to provoke success. In line with Lovering's (1999) critical view that much of the discussion around regional innovation system is little more than a debate about how to create collaborators, the findings of this thesis suggest that there is a need for such collaborations and interactions to have substance and quality.

More particularly, in the venture capital framework, the success of the investment depends 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). According to Peneder (2008) the accuracy of the allocation of resources depends on two critical factors: (i) the availability of information; and (ii) the ability to interpret information properly, i.e. knowledge. In addition, this thesis argues that the ability to access this information is of similar significance - condition (iii). If we assume that conditions (i) and (iii) have been meet in all UK regions, in the case of publicly backed venture capital funds, it appears that the second condition - the ability to interpret information properly - has been problematic. Despite the fact that publicly backed investment managers are more actively involved in information seeking - and perhaps acquiring - procedures (i.e. interact more often with innovation bodies than their counterparts from the private sector), they seem to be less capable of interpreting this information properly. Possible explanations of why this is happening lie with the different skills between publicly and privately backed fund professionals. Professionals from the public venture capital funds have a wider network of active contacts which enable them to reach valuable information, but they may not be as "smart" as their counterparts from the private sector in terms of adding value (Shäfer and Shilder 2009).

Second, according to cluster policy approaches, regions need to build on their competitive advantage with the aim of increasing indigenous capacity. Such approaches often encourage the implementation of targeted initiatives in sectors that are seen as having a competitive advantage in the region. Venture capital funds are often specialised in specific sectors allowing them to benefit

from a regional research institute or a cluster. As such, venture capital funds should be seen as an integral part of a dynamic regional innovation system. However, in the case of the public VC initiatives, funds were established without taking into consideration the regional innovation system, its specific needs, characteristics and indigenous competitive advantages.

Third, although the role of the firm has been seen as critical within the existing literature on regional innovation systems, the role of firm financing intermediaries has received considerably less analysis despite its recognition as a central actor of the system (Zook 2004). In line with Lovering's (1999) critical view on the sole emphasis of regional innovation policies on firms as the only type of regional economic actor, the findings of this thesis emphasise the equally important role of investors and of public sector in the innovation community.

A well functioning regional venture capital community is a major contribution to a flourishing regional innovation system as is evident from the examples of Cambridge and Silicon Valley. However, such venture capital communities are privately driven. The findings of this thesis suggest that venture capital communities which are publicly driven do not share the same attributes with privately run venture capital communities. In that respect, missing in the existing literature on venture capital and innovation is the role of the source of venture capital communities. In line with the pioneer work of Cooke (2001) on private regional innovation systems, this thesis provides evidence to support the argument that venture capital supports the regional innovation system to a greater extent when it is privately driven or when it involves private players.

In addition, current publicly backed schemes have been implemented by adopting a top down approach i.e. the central government created such schemes that could (in theory) be homogeneously implemented in each UK region. Such schemes did not allow for adjustments or changes to reflect regional heterogeneity. Although the aim of such initiatives was to increase regional entrepreneurial activity, the theoretical thinking behind them ignored the fundamentals of the evolutionary approaches that give space to regional complexities and allow regions to decide for themselves on their particular needs and implementation methods. Future initiatives need to be adjusted in different context, for example, in less developed regions such as Wales, initiatives related to venture capital investment must be accompanied by other measures aimed at fostering and supporting regional clusters of high-technology research, innovation, and small firm start ups.

8.2.2 Empirical contributions

In empirically pursuing the examination of the relationship between venture capital and regional innovation, this thesis mainly built on the following premises: the work of Mason and Harrison (2001, 2002) who found that there is large disparities amongst the UK regions in terms of venture capital investments, with London and South East dominating the industry; on pioneering work of Gompers and Lerner (2001) and Kortum and Lerner (2000) who found that venture capital spurs innovation, the work of Brander et al. (2010) on the importance of moderate government venture capital support in patents creation; and the work of various scholars that examined interactions within the VC community (Sorenson and Stuart 2001; Rosenberg 2002; Smith 2005; Powell et al. 2002; Pinch and Sunley 2009) .

However, in this thesis an attempt has been made to go beyond the work of those researchers in three ways. First, in their examination of the regional differences, Mason and Harrison (2001, 2002) focused only on the supply of VC in this regions and the potential impact of the publicly backed VC in a regional context; in contrast, although this thesis also focuses on the supply side, it investigates the combination of VC in these regions by providing a detailed analysis of the extent of VC public dependency of each UK region. It also elaborates on previous analysis undertaken by those researchers on the potential implications of the public sector domination in several UK regions. The regional dimension of the analysis is therefore of special interest as it is the first comprehensive analysis of the source of VC investments (public or private) for each UK region.

Second, Kortum and Lerner (2000) measured the impact of VC in innovation using patents as a proxy variable for business innovation. Barden et al. (2010) expanded the existing literature on the relationship between venture capital and patenting by including an additional parameter in this relationship, which is the source of venture capital (public or private). This thesis uses a much larger UK sample than Barden et al. (2010) and expands the literature by analysing the relation between patenting practices of VC backed firms paying particular attention to two aspects: first, their acquisition of venture finance and progress through the venture capital journey and second, the relationship between patent practices and source of VC finance in the UK regions.

Third, the literature review shows that there is a strong body of research concerned with VC-business interactions, mainly focuses on the relationship between venture capitalists and investee companies (Sapienza and Amason 1993; Smith 2005) and also the reasons that may influence such relationship (Gorman and Sahlman 1989; Sahlman 1990). However, the analysis of VC with other bodies outside the strictly VC-business framework is very scarce. This thesis extends the literature by

investigating, mapping and measuring the extent of interaction between venture capital funds with other members of the finance community such as business angel networks, banks, companies outside the portfolio. There is also little analysis on how the VC community interacts with the outside world. Therefore, this thesis provides the first detailed empirical investigation of the relationship between VC and other players of the innovation system such as universities incubators, research institutes, regional authorities etc. Although it does not analyse empirical factors that may be responsible for such relationship and it collects data from VC management only, it provides a new insight into the differences in the extent of interactions between different types of venture capitalists and the outside world. Existing studies do not distinguish between private and public funds and therefore their findings may not necessary apply to publicly backed funds since such funds often have additional or different to private funds objectives. Second, existing studies are mainly concerned with the likely impact that interactions between VC funds and other bodies may have on the fund's financial performance and therefore do not investigate the likely impact of these interactions in regional innovation. As a result, very little is currently known as to the role of the publicly VC backed funds in spurring innovation at the regional level.

The thesis thus seeks to explore whether locality is still important for interactions for VC professionals and how it may differ between regions led by publicly provided VC systems compared with these led by private VCs.

In addition, the relationship between the venture capital industry and regional governments and institutions of governance has been mainly explored from the point of the government's role (and the need) in supporting the industry (see Lerner 2002, 2009; Murray 2007). Overall, there has been very little research to date on mapping and understanding the relationships between these different bodies and how they may affect the overall innovation system (with the only exception of universities perhaps - substantial research has been carried out into the role of VC in stimulating university spin outs etc.). Various scholars suggest that substantial differences exist between regions' venture capital institutions; especially their ability to product and use tacit knowledge (Zook 2004). Based on Cooke's, Mason's and Zook's observations, this thesis provided evidence to support the relationship observed by Cooke et al. (2003) between public venture capital and regional innovation in the US, showing that less innovative regions also tend to rely on public venture capital in the UK .

8.3 Summary of research findings

8.3.1 Public venture capital investments

The first research question of the thesis was concerned with the changes in the supply of private sector venture capital and the supportive public interventions at the national and the regional level. At the national scale, the supply of venture capital recovered during the mid 2000s after its collapse in the wake of the dotcom boom in 2001, but fell back in 2008 with the onset of the financial crisis. During this period the provision of early stage venture capital has changed, with public sector venture capital funds becoming more important, largely as a result of the growth of co-investment schemes which invest alongside Business Angels and private sector funds. Both public sector funds investing on their own and private investors investing on their own have declined in both relative and absolute significance since 2004-2005. The composition of private sector investors has also changed, with funds declining in significance and various types of Business Angels (high net worth individuals and angel groups) becoming more important. At the regional scale, the disparity between regions has been widened in terms of private equity as a whole but it has been narrowed in terms of early stage investments. Several regions have more than their expected shares of early stage venture capital investments, measured by number of deals, mainly due to the increase in publicly backed investments. However, the high level of investment activity is largely a function of the public sector venture capital funds, either investing on their own or in conjunction with private sector investors. Indeed, over the period 2000-2008, the public sector has been involved in more than three-quarters of the early stage investments made in the midlands and north, rising to more than 90 percent in some regions in 2008. So, from a regional perspective the UK now appears to have two early stage venture capital markets. In London, the South East and, to a lesser extent, the East of England, private sector investors dominate investment activity, investing for the most part on their own rather than with public sector co-investors. This contrasts with the remainder of the UK where the early stage venture capital market is under-pinned by extensive public sector involvement. In some regions this takes the form of free-standing investments by public sector funds whereas in other regions it takes the form of co-investments with the private sector. Moreover, this gap between London and the South East and the rest of the country has widened since 2001, during periods of both declining and expanding venture capital investment activity.

The remarkable increase in co-investment activity is not surprising for various reasons. The most important reason is that publicly backed funds are obliged to co-invest with private funds due to state aid rules and due to the fact that one of their objectives is to leverage private money into the

market. Apart from this, there are other reasons that contribute to this unbalanced preferential of co-investments. First, publicly backed funds are fairly new concept in the UK. Although 3i was created in 1946, only at the beginning of the 21st century were a large number of funds created with the direct support of the government. Therefore, it is not yet an established industry that has proved itself in the market. Second, private funds perform significantly better than publicly backed funds in terms of financial returns (see NAO 2009) making them desirable co-investment partners. Third, anecdotal evidence suggests that professionals working at the publicly backed funds do not have the experience of those from the private sector, nor do they receive the same remuneration incentives. Forth, the objectives of a publicly backed fund quite often go beyond the financial returns and touch social aspects (with all the implications this may have in the skills of the personnel of the fund and the location and the industry of the funded companies). Fifth, all these parameters have created a vicious circle, as the top graded companies may first approach the private funds and if rejected turn to the public ones because they believe that they will get better support from the private professionals, better contacts with the market and more possibilities for an exit.

As mentioned earlier, the fact that the overwhelming majority of early-stage venture capital investments in many UK regions are publicly backed, in itself is not necessarily a cause for concern: if the alternative is sensible investments not being made, public intervention may be justified. However, the results of the NESTA and BVCA (2009) study imply that regions which are dominated by public VC investment will be overwhelmed by VC backed companies that do not perform much better than those that do not receive venture capital investments. In other words, regions that are heavily dependent on public investments may not be able to receive the benefits of a functional venture capital industry. This is also extended to innovation performance of these regions as chapter 6 indicates. The case study of Wales illuminates this further by showing that despite the significant presence of publicly backed investments, the regional venture capital market has not succeeded in attracting private investors, capitalising on the existing knowledge base of the region or making significant number of successful exits. The findings from this case study suggest that the environment that Wales start-ups face could be a major contributor to the absence of a vibrant venture capital community in the region. Efforts to improve the conditions faced by those young innovative companies that could become the 'google' of tomorrow should be made.

8.3.2 Relationship between venture capital and innovation

In order to investigate the suggestion that publicly backed investments may affect the innovation performance of the regions, this thesis also analysed the relationship between VC activity and volume of innovation and investigated whether this relationship is affected by the different types of

venture capital. More particularly, the analysis examined whether increases in venture capital activity is positively associated with increases in volume of innovation. A strong and positive relationship between VC activity and volume of innovation was observed. This part of the thesis was also concerned with regional variations in VC activity and innovation performance of the twelve UK regions.

An important finding of this analysis which is in line with the literature is that there is a clear relationship between VC and patents. Companies with patents are more likely to secure follow up VC finance compared with companies without patents. Due to the importance of patents in the VC investments, the analysis examined whether there are any factors that may affect the company's possession of a patent, such as where the company is based, industry operation, source of VC finance, amounts received and stage of finance. The results of the analysis show that there are significant variations between companies that operate in different industries. Several industries have significant higher number of patents. The thesis also examined the geographical aspect and the volume of patents for companies that received VC investments at each particular region and found that there are significant differences amongst UK regions.

The study also examined the role of difference sources of VC investment (public or private) in supporting innovation. The empirical results suggest that co-investments are positively related with companies with patents while solely public investments are negatively related with patents. This is in line with Brander et al. (2010) work which illustrates that enterprises with moderate government venture capital support, outperform enterprises with only private venture capital support and those with extensive government venture capital support both in value creation and patent creation.

The findings of this chapter suggest that publicly backed funds do not support innovation to the same extent that private funds do, when they invest alone, which has important implications for regional development. Firstly, innovative companies that are based in regions with high dependency on public VC funds may find it more difficult to raise VC finance compared with similar companies based in regions with strong presence of private VC funds. As a result, such companies may decide to relocate to regions with active private VC markets.

Secondly, co-investments (when public and private funds invest together) are more likely to back companies with the potential to innovate than private or solely public investments. As a result, regions with proportionally higher volume of co-investments would also demonstrate a higher volume of VC backed companies with the potential to innovate. From a policy perspective, this

finding suggests that from an innovation point of view, public free standing investments should be minimised while co-investments should be further encouraged.

In that respect, when a region is dominated by publicly backed funds, it would be hard for these funds to find co-investors from the private sector and therefore the amount of co-investments would be limited. Alternatively, public funds in publicly dominated regions should be encouraged to attract private investments from outside investors. They could be seen as the pipeline of valuable information about investable opportunities in peripheral regions to London and South East based private VC funds. Again, the study of Wales highlights the need for regional publicly backed funds to expand their remits outside their base region. While there are encouraging signs that Finance Wales is expanding outside the regional borders, its success in attracting private co-investors into Wales cannot be taken for granted without an improvement in the regional entrepreneurial environment. Smaller publicly backed funds that do not possess the human or financial capital of Finance Wales should rethink their operational model and seek to establish stronger links with private venture capital funds from the south east of the country.

The statistically significant negative association between solely publicly backed investments and patents, is not explained by sectoral structures or investments characteristics: differences between regions, industry focus, investments size or investments stage. Such differences could be the result of some unmeasured investment characteristics or the environment in which funds operate. The plausibility of this suggestion was examined in chapter 7.

8.3.3 Ecology of interactions

The final research question of the thesis investigated whether the environment in which funds operate may explain observed differences by examining the ecology of interaction between different types of venture capital and regional innovation systems.

An important aim of government investment in VC (including regional venture funds) has been to attract funds from private investors, and develop a vibrant private regional venture capital sector. The evidence from the UK regions is that this has not happened as shown in previous chapters. Outside London, Cambridge and the South East, public sector VC investments vastly outweigh private sector ones. There may be various reasons for such failure such as the quality of regional business (demand side problem), competence of VC professionals, structure of the publicly backed funds or regional environment in which the funds operate. An attempt has been made to explain what drives these differences in the performance of the funds by examining the dynamics of the

regional environment, the attitudinal and behavioural characteristics of the different types of venture capital funds.

Three important findings emerged from this analysis. First, public dependence is strongly and significantly associated with higher volumes of interactions with the outside world. The more publicly dependent a fund is, the more it interacts with other players of the innovation system. This suggests that publicly backed venture capitalists have the capacity to activate the search and screening process over a wide network of contacts within a geographical space and can deploy the extensive reach of their networks to identify and evaluate investments opportunities.

Second, the role of proximity is still important within the VC industry. Venture capitalists from both the private and the public sector, are more likely to interact with their counterparts from the same region.

Third, there is some evidence to suggest that operators of publicly backed funds are lacking close connections with their counterparts from the private sectors. This may have implications in their ability to approach and attract private heavy weighted venture capital funds and LPs that can provide follow on investments or raise further funding for the fund.

This development reinforces earlier suggestions that there are currently two distinctive venture capital communities in the UK. One which is privately led and includes London, South East and East of England, and one which is publicly backed led and includes all the remaining regions. The distinction between the two venture capital markets is not limited to the volume of VC activity and other innovation indicators but it is expanded into the ecology of interactions between venture capitalists and other players of the regional innovation system.

There are some common characteristics in the way that the two communities operate and also some distinctive differences. On one hand, venture capitalists from both communities consider personal business contact as the main source of deals. They also treat management expertise as the most important strength of a business opportunity followed by the customers and market potential of the product, and their most preferred industry for investments is software followed by medical devices.

On the other hand, venture capitalists employed by a publicly backed fund, interact with the other bodies from the VC community more often than the private venture capitalists do and are more engaged with the innovation community. Publicly backed venture capital professionals interact with public funds within their region and business angel networks substantially more than their private counterparts. Publicly backed venture capitalists interact twice as much with regional R&D institutes, RDAs, law companies, specialists, managers of technology parks, and IP protection bodies

compared with their counterparts from the private sector. This result may be explained by the fact that professionals from the publicly backed funds have the – sometime implied – objective to interact with other players of the regional innovation system in order to foster the entrepreneurial and innovation community. In order to meet these objectives, such professionals have established links with the above bodies. Alternatively, public organisations such as RDA, technology parks and incubators did not manage to attract the interest of the private VC funds. This is open to two interpretations. First, either the professionals of these bodies are not active enough in the area and have not made the private VC funds aware of their pool of opportunities, or second these organisations do not contain a pool of business proposals that the private venture capitalist would be interested in investing.

Overall, public funds are mainly responsible for most of the interaction that is taking place between the business angel networks and the formal VC community. This is an important finding that policy makers need to take into consideration given the fact that Business Angels are emerging as prominent players in the early stage risk finance community. This relationship is also reflected in the source of deals.

It is widely acknowledged that interactions between venture capitalists and other players promotes tacit knowledge (Zook 2004), but the results of this thesis suggests that interaction on its own is not enough to provoke success. Although publicly backed venture capitalists interact to a greater extent than the private counterparts, they experience less success (measured as financial performance or business performance), (NAO 2009; NESTA 2009). The financial performance of the publicly backed fund has been negative. According to the NAO, most of the publicly backed funds recorded negative returns. Although there is no comprehensive analysis as to what have caused publicly backed funds negative performance, it may be suggested that the publicly backed funds have invested in companies without great potential to grow.

Recent work by NESTA (2010a) has shown that for UK firms, being innovative is strongly associated with high growth, with innovative businesses growing twice as fast as non-innovative ones. Given this strong linkage between innovation and growth, the evidence of this thesis provide some support to the argument that publicly backed funds have invested in companies with less potential to grow since companies that received only investments from publicly backed funds did not have the same innovation potential as those that received investments from private funds. However, when public funds co-invest with private funds, are more likely to invest in companies with the potential to innovate compared with those that the private funds invest in.

8.3.4 The region of Wales

The region of Wales represents a publicly led regional innovation system in which all major players are either a public organisation or publicly backed entities. The case of Finance Wales is not an exception. Clearly, in the absence of Finance Wales, venture capital activity in Wales would have been far less as there is no evidence that Finance Wales has crowded out private investors coming from the rest of the region.

The innovation system in Wales is publicly oriented and therefore it is not surprising that the venture capital community in Wales is dominated by a publicly backed fund, namely Finance Wales. It is however important to note that the Wales venture capital community differs from other publicly dominated venture capital communities in English regions. More particularly, the public funds that operate in English regions are relatively small and have limited ability to follow up their investments. In contrast, Finance Wales, which is the main investment vehicle in Wales, is a large and established financial institution with larger funds under management. Despite this important difference, the Wales venture capital community shares several characteristics with those in other publicly dominated regions.

More particularly, publicly backed investments count for the vast majority of all venture capital investments made in Wales. In addition, venture capital professionals in Wales exhibit similar behaviour characteristics with their counterparts in other publicly oriented venture capital regions, in terms of the relationship to the "external environment". The ecology of interactions amongst venture capitalists and other players of the regional innovation system in Wales shares similar characteristics with the ecology of interaction of the average publicly backed UK region.

However, Welsh venture capital professionals interact significantly less with several bodies of the finance community compared with their counterparts from both the public and the private sector (companies outside their portfolio, other private venture capital funds inside or outside Wales and other public venture capital funds within Wales). Although Finance Wales shares common organisational characteristics with private VC funds, it is clearly lagging a more active involvement with the private VC community which may be due to the absence of privately own VC funds operating in the region. In addition, and as discussed earlier, publicly backed funds often have social objectives that need to be met , as well as an ethos of social responsibility. Finance Wales is not an exception. This has implications for its operational activities and the skills of its personnel. As a publicly backed fund, FW is also constrained by state aid rules and geographical restrictions (i.e. it can only invest in Wales).

Interestingly, Wales is the only publicly oriented venture capital community with a relatively 'fair share' of early stage venture capital investments (in both, number of deals and amounts invested), perhaps reflecting the ability of FW to make more investments due to its relatively larger assets under management. This may suggests that there is no shortage in the supply of finance to Welsh based companies seeking venture capital finance, or at least that this shortage, if exists, it is smaller than in other publicly oriented regions.

Nevertheless, there is still an absence of a vibrant venture capital community in Wales, capable of attracting private investors into the market and capitalising on the excellent research outcomes that its main university is undoubtedly capable of producing.

This suggests that the Welsh environment could be largely responsible for the underdevelopment of a vibrant venture capital community. For example, the research outputs from the universities or research laboratories cannot be effectively commercialised within the regional innovation system. There are three main reasons that support this argument. First, despite the establishment of FW and the relatively large number of early stage investments to Welsh companies, it is clear that the there is still an absence of a vibrant privately led VC community in the region. Second, there are a relatively small number of investments made to Welsh companies by funds located outside Wales (which again may indicate the lack of investable opportunities in Wales). Finally, despite the history of venture capital investments, FW has not had numerous successful exits which is the ultimate indication of a successful venture capital environment.

The latter point is of particular importance for two reasons. First, it indicates either a poor performance of FW venture capital investment managers or a poor local business environment incapable of producing companies that can exit. However, FW is performing well in other types of financial instruments such as mezzanine finance (interviews), indicating the calibre of its personnel. Second, without a successful track record, it would be difficult (if not impossible) for FW to raise money from private investors (limited partners) if it wishes to become independent from the public sector. It is the case of a 'vicious circle' where neither private funds can be established in Wales nor it is sensible to abolish the existing public funds. Without publicly backed funds, Wales would have been in the bottom part of the list of venture capital investments by region in the UK.

Even if Finance Wales decides to be privatised (following the example of the Scottish Equity Partners, which has been privatised and now invests without regional restrictions), it may find it difficult to effectively operate within a publicly oriented regional innovation system that does not spur entrepreneurial activity. Realising the issues provoked by regional constraints, Finance Wales

has already expanded to other regions of the UK, opening offices in the North West and North East (after two successful applications to run local funds in these two regions). Although these funds are not venture capital funds, FW is laying the ground for a more active involvement in the venture capital market if at a later stage its decides to pursue this. Interestingly, the aspiration of Finance Wales is to eventually become a self-sustained privately led organisation (interviews).This is a positive sign indicating the professionalisation of the organisation which, if it is to be successful in long term, it needs to expand outside the regional borders.

The evidence shows the progress that Wales has made over the last two decades, but it also highlights the important challenges that lie ahead. Whether the Welsh venture capital industry will be able to match the activity (in terms of quality and volume) of the privately led regional venture capital markets in the next decade will depend on the decisions taken by fund managers and policymakers among others. The findings in this case study can help inform investors' and fund managers' decisions, but they have particularly important implications for Wales's policymakers. Policy makers should be more interested in improving the Welsh entrepreneurial environment rather than simply pouring more money into the market by establishing new publicly backed funds. Wales does not need more investments in venture capital, but it is essential that the investments made are made to good companies. Therefore more actions need to be taken in order to improve the quality of the entrepreneurial environment in the region.

A future research study could look in more detail at the entrepreneurial environment of Wales, by empirically examining the characteristics of the portfolio companies of FW and other funds operating in the region. What are the characteristics of companies that Welsh venture capitalists back and how do they compare with those backed by other publicly backed and private venture capital funds around the country? How can the lessons learned from the Wales experience in terms of the role of venture capital and regional innovation, influence relevant policies in other less developed regions?

8.4 Policy implications and contributions

The thesis contributes to the literature on the role of government in fostering venture capital activity by examining the investments and source of finance in the UK and its regions. Perhaps the most important contribution is the investigation of the relation between the type of VC funds (private or public) and the investment activities in which they are engaged. The data allows the relations between private and public VC investments to be compared across regions and therefore brings some light into the underdeveloped literature on the regional variations in venture capital markets.

However, any attempt to produce policy recommendation in the area must take into account the complexity of the venture capital investment, in fact:

"given the complexity, suggesting how venture capitalists should respond to regional variations in funding, and recommending government policies to promote regional supplies of risk capital – let alone high technology based economic development – are far from straightforward issues" (Martin et al. 2001, p.25).

The findings of this thesis highlight the highly localised nature of venture capital activity and this has a variety of implications for policy makers wishing to stimulate venture capital activity at the regional level. Those regions that are dependent on the public sector for early stage venture capital therefore face two challenges. First, there is no evidence to suggest that this approach has been effective in stimulating indigenous private investments and currently publicly backed deals dominate several regional VC markets. Second, existing regional venture capital funds are approaching their lifespan and the limitations of regionally focused funds have been widely outlined (Murray 1998, 2007; NESTA 2009, 2009a). The limited success of the current public interventions can be attributed to four main assumptions made by their designers.

First, the regional dimension of the schemes was based in the implicit assumption that administrative boundaries are a sensible definition of regions. However, "region" is both not clearly understood or unequivocally defined (Bristow 2010). Especially in the field of entrepreneurship and venture capital, regional restrictions have been seen as a major drawback in the success of venture capital activity (NESTA 2009). Regions are now shaped more by relational flows of innovation and by their networks, rather than their geographical or administrative boundaries (see Uyarra 2007).

Second, such initiatives were based on the assumption that all regions contain an untapped pool of smart entrepreneurs (investable opportunities) and such initiatives will unleash a wave of new entrepreneurs. It may well be true that all regions should contain some very smart entrepreneurs that cannot progress due to lack of finance. However, this does not mean that the region has or can develop an entrepreneurial culture by simply increasing the supply of finance in the region. This is of course not to say that all regions without an existing entrepreneurial culture should be left unsupported. However, only regions with strong evidence of development potential can truly benefit from venture capital funds. Such evidence may include strong research led institutions, developed infrastructure and established regional ability to absorb new knowledge. In less developed regions, initiatives related to venture capital investment must be accompanied by other

measures aimed at fostering and supporting regional clusters of high-technology research, innovation, and small firm start ups.

Third, this leads to a further assumption which is related to the heterogeneity of regions. Uneven development and regional heterogeneity has been in the centre of the debate between regional geographers and economist for several decades. A major drawback in the success of all government schemes has been the remarkable failure of policy makers to spot regional heterogeneity within the UK. The current schemes ignore regional differences and characteristics and treat all regions in the same away. For example, the schemes had the same objectives whether there were established in London or in North East. This is a fundamental error that the notion of a simple supply gap overlooks. In the words of Martin et al. (2005):

"the way in which the localised form of the industry is based on a dynamic learning process in which demand and supply processes combine with their embeddedness in social networks and individual perceptions in a mutually reinforcing way. Less-favoured regions, with low investment rates, few local venture capital firms, and a dearth of experienced specialist intermediaries, may thus be trapped in a situation of both depressed demand for and supply of venture capital investment" (Martin et al. 2005, p.1).

This leads to the fourth assumption related to the design of the schemes, and more particularly the tendency of these policies – both in the UK and elsewhere – to be overwhelmingly supply-side in approach, with little attention given to the demand side (Beatty and Fothergill 2004). As Queen (2002) noted:

"*the temptation of all policy makers is to target the superficially attractive short-term policy of subsidised venture capital on the 'supply side'. Tempting as it might be, this should be avoided if more sustainable growth businesses are the objective"* (Queen 2002, p.5).

8.4.1 What kind of policy is needed?

As shown in chapter 5, public funds now participate in around 42% of venture capital deals in the UK. However it is questionable whether public financing would ever invest in ventures otherwise ignored by other financiers (Peneder 2008). There is a need for such initiatives to change in order to incentivise private investments in the early stage market, foster the demand side and accommodate regional heterogeneity.

Incentivise private investments

One of the primary objectives of the government intervention in the area has been to increase the availability of finance to early stage companies by leveraging private money and sharing the inherent risk that early stage investments entail. However, what really determines the supply of venture capital according to Gompers and Lerner is:

"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).

In fact, the government schemes' adopted a subordinate role which allowed greater returns to be made by private investors. However, even if government interventions made it cheaper for private funds to invest in early stage, private investors are continuing to leave the early stage and prefer to invest in the later stages where return potential is higher. This is mainly due to the very poor returns made in the early stage market in recent years (NESTA 2011). The involvement of the General Partner and any private sector Limited Partners in a publicly backed fund will require the engineering of more attractive profit expectations in order for them to be willing to participate (Maula and Murray 2003). If the compensation structure is identical to those of venture capital funds operating at other (later) stages of the investment cycle, the returns to the management partners of a governmental program are likely to be lower (Jääskeläinen et al. 2002).

As a result, the government's attempt to increase the supply of private money into the early stage finance has been approached from the wrong angle and regardless of the volumes of money the government allocates to the early stage finance, unless returns are favourable, private investors will refrain from the market and future governments will keep subsiding the industry.

Clearly, leveraging private capital is better value for the Government. The challenge is to provide terms on which private capital will be willing to invest in the early stage market. The low returns in the venture capital market makes them unattractive for private investments as it entails high risks and small rewards. The risk is inherent and it will always remain in this area of the market but market professionals and high-skilled venture capital investors can reduce it. The issue of small rewards to private investors is something that the government can effectively deal with by providing the appropriate structure to diminish low returns.

Avoid geographical restrictions

A number of publicly backed funds are geographically focused, with a requirement to concentrate on certain English regions or UK nations. Although venture capital certainly has a role to play in stimulating regional economies, limiting funds to regions has significant risks. It constrains funds' ability to source high-quality investments as economic activity frequently crosses the borders between regions, which in the UK are relatively small in geographic terms. This means that a fund that can only invest in its local region is likely to turn down many potentially attractive but non-local investments it encounters, reducing its chances of striking good deals. In addition, since venture capital is *a priori* locally concentrated (see Mason 2007 and Chen et al. 2010), there is no need to impose artificial regional restrictions.

Foster the demand side

The lack of private VC investments in several regions is driven by the lack of investable opportunities in these regions. This requires grants, mentoring and support that will prepare companies to receive VC finance. First, there is a need to foster the development of regionally-based angel groups. With traditional venture capital funds facing challenges to their investment model, angel groups are now assuming a much more significant role as a source of early stage venture capital. Equally important is that their hands-on involvement plays a significant accreditation role and moves their investee businesses to the point where they are potentially investable by venture capital firms (Madill et al. 2005).

Second, the pipeline of information between traditional sources of investable opportunities such as universities, incubators, laboratories, technology parks and VC professionals is not well established in the UK and needs to be strengthened. Given the emphasis that venture capitalists place on trusted networks for deal referrals, there is a need to develop funding 'pipelines' (Bathelt et al. 2004) between the key players in the regional entrepreneurial eco-systems (e.g. universities, incubators, angel groups, local venture capital funds) and non-local private sector venture capital sources.

Third, the objectives of the public funds should vary according to regional needs. Less favoured regions may not fully benefit from a conventional venture capital fund. Instead, funds established in these regions should assume different responsibilities. For example, public venture capital programs could play a role in certifying new firms to outside investors (Lerner 2002). This is one way to overcome the informational asymmetries problem identified in the literature. The idea is that

government programs can identify and support the creation of new firms in industries that do not attract private venture capital (for example, technology-intensive industries).

Promote co-investment schemes

It is essential that a fully functional regional innovation system should provide business finance through vehicles based in partnership between public and private players of the regional innovation system. All the evidence from this thesis suggests that the investment model that encourages public private co-investments seems to be the most appropriate for various reasons. Venture capitalists from public funds may not have the skills required for nurturing high growth ventures. Therefore, there is a need to attract highly qualified and experienced private VC professionals in the regions. Co-investment is a learning process for the public funds and eventually professionals from the public funds will acquire the same skills as their private counterparts by syndicating with them (as it happens when local funds syndicate with international funds, see Chemmanur et al. 2010). Co-investment schemes also help publicly backed VCs to establish a track record that will eventually allow them to attract better quality businesses and raise further capital from private LPs.

Public fund venture capitalists should be seen as conduit of information and deal flow between the innovation community and the venture capital community. They have the ability to mobilise their network but perhaps they do not have as yet the ability to identify good investment opportunities or effectively support their portfolio companies. It should be a two way process: a learning process for the public venture capitalists to become better professionals, and for private venture capitalists a way of making the connection with the innovation community (e.g. universities, laboratories and incubators) that still remains a largely untapped source of innovative businesses.

8.5 Future research questions

The research revealed several research questions that could be addressed in future studies. First, there is an assumption amongst the VC industry stakeholders that top graded companies may first approach the private funds and if rejected turn into the public ones and this creates a vicious circle for the public venture capital funds as they will struggle to perform well. At the moment, there is not any comprehensive analysis which examines the differences in the quality of the companies when approaching private and publicly backed funds. This will be an interesting future research topic.

This analysis of the relationship between venture capital and innovation has several important limitations. First, the time when the company was granted the patent is not known. Therefore, it was not possible with the given data to examine whether the patent was granted before or after the

VC investment. A future study could capture the date of patent application and associate it with the date of VC investment. Second, although the literature accepts that patent creation is an important figure for innovation, additional proxies for innovation could be used in future analysis such as licenses, trademarks, number of new products in the market, copyrights etc. Third, additional depended variables could be used in future analysis such as the performance of the VC backed companies and its association with patent and public or private investment. In this sense, performance could be defined as company turnover, employment growth etc. Finally, a further research could control for other characteristics of the firm that may affect its innovation outputs, such as size of firm, foreign ownership, export activity, openness, structure, R&D activity etc.

One of the limitations of this ecology of interaction analysis has been the relatively small sample size which is a result of the reluctance of venture capitalists to participate in academic studies. Several other limitations should also be kept in mind in interpreting the results of this study. First, because the data is based on self-reports, one must be cautious as regards their analysis and interpretation. Future studies may seek to supplement the self-reported measures used in this study with objective measures of interactions (such as number of emails exchanged, number of meetings attended, duration of telephone calls, and number of visits to the sites).

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10 APPENDICES

10.1 - Appendix I: Venture capital Government schemes

Regional Venture Capital Funds (RVCFs)

RVCFs established in 2001 in nine UK regions in order to encourage start-ups and early stage investments. They are managed by fully commercial VC management companies

The RVCFs are limited to investing £250,000 at a time and may not invest more than £500,000 in a single company. They are also required to be the first source of institutional capital, which means they are generally able only to co-invest with angel networks rather than other venture capital providers. RVCFs have an implicit social motive; they are intended to maximise profit at the same time as being required to invest within certain size parameters as part of the government's ambition to encourage more private sector capital to address an equity size gap.

The RVCFs do not have specialist focuses, although some of them have made technology investments. By and large, the limit on the size of investment they can make prohibits them from investing in technology because it generally requires greater capital capacity. They also lack the resource to pay for the technical skills needed for effective specialist investing.

In order to assist fund managers to attract private sector investors, the government decided to subordinate its investment position by firstly putting a cap on its investment return, thereby boosting the anticipated return to private sector investor and the EIF along with agreeing to act as 'first loss'. This means that, in the event of an erosion of a fund's capital base, the public investment suffers the loss first.

Enterprise Capital Funds (ECFs)

ECFs were launched in 2003 but since then there have been several rounds. The concept of Enterprise Capital Funds (ECFs) aims to improve access to growth capital for small and medium-sized enterprises by applying a modified US Small Business Investment Company (SBIC) model to the UK by: i) bringing more entrepreneurial investors into the management of funds aimed at smaller, early

stage deals; ii) offering incentives to investors to make these investments and; iii) enhancing the impact of business angel networks in providing sources of risk capital and expertise to SMEs.

Early Growth Funds (EGFs)

This programme was developed to encourage risk funding for start-ups and growth firms. The objective: to increase the availability of small amounts of risk capital of on average £50,000 for innovative and knowledge intensive businesses, as well as for other growth businesses. EGFs are able to make maximum initial investments of up to £100,000. Most funds require matched private sector investment to at least the same amount as Early Growth Fund investment.

University Challenge Seed Funds (UCSFs)

The aim of the University Challenge Seed Fund Scheme is to fill a funding gap in the UK in the provision of finance for bringing university research initiatives in science and engineering to the point where their commercial viability can be demonstrated. Certain charities and the Government have contributed around £50 million to the scheme. These funds are divided into 15 University Challenge Seed Funds that have been donated to individual universities or consortia and each one of these has to provide 25% of the total fund from its own resources. Maximum initial investments of up to £100k. Maximum investment per firm: £250k

European Regional Development Fund (ERDF)

ERDF supported venture capital and loan funds in Scotland (including the Scottish Co-Investment fund) and Wales (Finance Wales). The North West, Yorkshire and the Humber, South West, North East and West Midlands have all used ERDF Objective 1 and/or Objective 2 fund monies to develop additional specific solutions for their regions.

Fiscal incentives

Venture capital trusts (VCTs)

The government attempted to address the aggregate supply-side problem by using fiscal incentives to draw more capital into the venture sector with the creation of venture capital trusts (VCTs) in the mid-1990s

Venture capital trusts (VCTs) are listed funds that invest according to a set of criteria to qualify for privileged tax treatment. The source of their capital is typically high net worth individuals or retail investors. The rules attached to VCT qualification require a large proportion of the fund to be

invested within a given period of time. This means that they often have a few years of high levels of activity and then a much slower stretch while the investments are harvested.

Many VCTs concentrate their investment activity on AIM-listed companies or buy-out opportunities, often pooling their resources to finance much larger deals than would be achievable or allowable from a single fund. A number of VCT managers have more than one fund under management, often with similar investment strategies. These are sometimes managed by the same team and often invest alongside one another

Enterprise Investment Scheme EIS

EIS was introduced in January 1994 as the natural successor to the Business Expansion Scheme (BES). It was set up by the Government in order to encourage Business Angels to invest in certain types of smaller unquoted UK companies. The Enterprise Investment Scheme (EIS) aims to incentivise investment in smaller, higher-risk companies that have growth potential but sometimes struggle to raise finance. The EIS plays a significant role in the provision of venture capital for small businesses, having helped rise over £6.1 billion, invested in over 14,000 companies. In 2008 the annual investor limit was raised to £500,000 (subject to State aid approval).

10.2 Appendix II: Data sources and analysis

Venture capital deals data

The main challenge when undertaking research on venture capital is the availability of suitable data (Hellman and Puri 2002; Mckenzie and Janeway 2008). To overcome this challenge, several data sources have been examined for this study:

Thomson One

Thomson One (previous known as Venturexpert), which is a division of Venture Economics, is a private equity dataset provided by Reuters. Venture Economics receives quarterly reports from VC organizations and from major institutional investors on their portfolio holdings and, in exchange, provides summary data on investments and returns (Ueda and Hirukawa 2006). VentureXpert reports daily VC investment data from 1960 to date.

VentureSource

Dow Jones' VentureSource collects data on firms that have obtained venture capital finance since 1987. The database include the identity of the key founders, as well as the industry, strategy, employment, financial history, and revenues of the company. Data on the firms are updated and validated through monthly contacts with investors and companies. The companies are initially identified from a wide variety of sources, including trade publications, company web pages, and telephone contacts with venture investors. Venture Source then collects information about the businesses through interviews with venture capitalists and entrepreneur (Gompers et al. 2010).

Library House

The Library House database reports individual investments along with various additional information on the investor and business which enabled customised tables to be generated. The availability of such information on individual deals allows considerable flexibility in analysis. However, its coverage is restricted to publicly reported investments, with attendant limitations in information capture and classification. It is important to note that Library House's coverage of investment activity is narrower than that of the BVCA, and in particular does not extend to private equity investments. In addition, its database is built up from reported investments and so does not capture all the investments that BVCA reports in its annual investments activity reports. In addition, the amount of information that is provided about each investment in Library House's database is limited, which restricts the amount of disaggregation possible. On the other hand, it does capture some

investments, notably those by angel groups and high net worth individuals making large business angel investments, which are not included in BVCA investment statistics. However, there is no source which provides a comprehensive coverage of angel investments (Mason and Harrison, 2008). Library House classifies its investments in terms of financing rounds rather than stages of finance. However, it does identify companies at the product development stages, defined as companies that have produced prototypes with a product being improved for commercialisation.

The Library House database disaggregates the type of investments into two categories:

- Those involving one or more private sector investors. This category primarily captures venture capital firms, but also identifies investments made by some types of Business Angels, notably investor networks (e.g. angel syndicates), family offices and named and un-named high net worth individuals. On account of their size these investments are much more visible than those of typical Business Angels. However, a key limitation of the data is that investments by Business Angels are only identified where they have co-invested with either private or public sector funds.
- Those involving one or more publicly backed funds (e.g. Regional Venture Capital Funds, University Challenge Funds). These are funds which have received some or all of their capital from the public sector, including central government departments, regional development agencies and the European Union (e.g. ERDF). They are normally managed by independent fund managers.

Taking into account the limitation of each dataset, it was decided to proceed with the Library House dataset for three reasons. First, while all commercial databases capture private equity investments, Library House concentrated solely on the venture capital and especially at the early stage market, which is our area of interest. Second, Library House was the only database that allowed the user to identify investment deals in which one or more publicly backed funds participated. Finally, Library House included details on Business Angel investments when there were part of a syndicate with a private or publicly backed fund.

As a result, using Library House database, a dataset of 4117 individual investments to 2359 UK based companies spread to all UK regions for the period 2000-2008 was created. The period covered in the analysis, 2000-2008 was determined by data availability.

This information has allowed for the classification of investments into the following categories:

- Deals involving solely private sector investors. This includes both venture capital funds and Business Angels.
- Deals solely made by publicly-backed funds.

- Deals - which are termed as *co-investments* here - in which one or more private sector investors has invested alongside one or more public sector funds. Investments in this category include both *ad hoc* syndications between public sector funds and private investors, and also investments involving Co-Investment Funds that have been established specifically to invest alongside private investors.

Patent data

The UK Patent Office provides access to the European Patent Office (EPO) database through an online facility. EPO database contains information of patents granted at UK patent office. For the empirical analysis, the patent data was sorted by both year of application and year of grant. Each company from the Library House database has been hand-checked to identify which of the 2359 companies that received one or more of the 4117 individual VC investments had received or applied for a patent. One complication was to accurately match the names of the companies in the two datasets (Library House and EPO). When there was a difference in the company name, additional information on the company location and industry operation were cross checked. In few cases that there was still ambiguity, companies were excluded from the analysis.

Survey data

The data collected for this study included responses to a questionnaire from 50 different venture capitalists. Using the BVCA directory, commercial databases, venture capital funds websites, government websites such as BIS and Capital for Enterprise, and utilising personal knowledge of the market, it was possible to identify individual venture capitalists.

The venture capitalists were geographically dispersed across the UK and in a variety of high tech industries. In order to minimise sample bias each venture capitalist was asked to fill out the questionnaire for the fund that he or she is most heavily involved in (GPs often manage more than one venture capital fund). The survey was restricted to venture capitalists that mainly invest in seed and very early stage companies. This allowed the research to focus exclusively on the interactions of the key individuals within the early stage technology venture capital community and to control for the variations on the findings that the inclusion of other sectors might have caused (e.g. retail sector).

As a starting point, 48 early stage venture capital funds were identified and the employees from 43 of them were contacted. Those funds contacted met the criteria of being sufficiently sized, active in the last three years, focused on high tech innovative companies and invest in seed, start-up, early

growth, late growth and expansion stage. Five funds were either closed or too small (i.e. less than £5m). Using desk research (internet, brochures and the BVCA directory) 309 individual venture capitalists that worked in these 43 early stage venture capital fund were identified. These funds are specialised in high technology and innovative ventures and are members of the British Venture Capital Association (BVCA). Correct and update details were acquired for 273 of them. A list of the funds that took part in the survey together with copy of the questionnaire can be found in appendix II.

The questionaire itself was developed in three stages. In the first stage two academics were consulted and asked to provide feedback on the draft questionnaire. At a second stage, the revised questionaire was presented to five venture capitalists and similalry, their feedback was provided. During this process several questions were changed or added. When the questionnaire was ready two venture capitalists were asked to complete it and provide feedback.

The questionnaire was sent out via personalised emails in an electronic format. The survey was completed in four stages, the first stage took place on 08-09 July 2009, the second stage on 15-16 July 2009, the third on 22-23 July 2009 and a final reminder was sent out on the 27th July 2009. This was then followed by a number of personal telephone calls to various selected individuals to encourage them to complete the survey or forward the questionnaire to the appropriate person at the fund.

During the survey completion, some individuals were reluctant to answer the questions either because they did know the answers to some of the questions or thought that they did not need to complete the survey because a colleague of them completed it already on behalf of the VC fund. Indeed, several emails were received stating that the answer to the survey represented all the staff from the fund.

Table 45: Response rate

	Value	**Percentage**
Total number of people identified as relevant to complete the survey	368	
Total number of people contacted	309	100.00%
Total number of valid email addresses	273	88.35%
Total number of responses related to the number of people contacted	52	16.8%

Total number of responses as a percentage of valid email addresses	52	19%
Total number of fully completed responses	50	

The response rate of completed questionnaires is 19 percent. Due to the sensitivity of the industry the questionnaire was completed on an anonymous basis however, participants were invited to complete the name of their fund and their job title and a few of them did. Therefore, it is known that venture capitalists from at least 20 named venture capital funds took part in the survey (49 percent of contacted funds). The remaining 30 questionnaires were completed by venture capitalists from different or the same funds.

Therefore, the response rate of 19 percent of the venture capitalists contacted represents a much larger sample of the contacted individuals and at least 49 percent of the venture capital funds that were contacted and currently operate in the early stage market and invest in high technology and innovative companies.

10.2.1 Descriptive statistics and sample bias control

In order to check whether the sample generated is representative of the population of UK early stage venture capitalists in 2009, a number of tests were conducted. First, the study sample was compared with the population on two characteristics, geographical distribution and size.

Geographical coverage

Table 46: Geographical representation of the sample

Early stage (2008)	Amount invested (£m) BVCA	%	No of responses in the study sample	%
South East	64	18%	5	11%
London	172	48%	18	38%
South West	12	3%	4	9%
East of England	20	6%	3	6%
West Midlands	12	3%	4	9%
East Midlands	9	3%	0	0%
Yorkshire	5	1%	3	6%
North West	23	6%	2	4%
North East	10	3%	1	2%
Scotland	24	7%	2	4%
Wales	2	1%	5	11%
Northern Ireland	7	2%	0	0%
	360	100%	47*	100%

* 3 venture capitalists did not indicate the region they are based

BVCA data was used to measure the proportion of amount invested in each UK region in 2008. The results are illustrated in the third column of the above table. The last column of the table illustrates the proportion of responses by each UK region. With the exeption of Wales which has provided more responses than expected (perhaps due to personal links) the percentages between the two proportion columns do not significanly vary. In order to minimise bias in the geographical sample , two responses from Wales were randomly excluded.

10.2.1.1 Chi-square goodness of fit analysis

A chi-square goodness of fit test allows us to test whether the observed proportions for a categorical variable differ from hypothesized proportions. For assume that the amounts invested in each region, will be closely correlated to the number of venture capitalists operating in this region (South East 18%, London 48%, South West 3%, East of England 6%, West Midlands 3%, East Midlands 3%, Yorkshire 1%, North West 6%, North East 3%, Scotland 7%, Wales 1%, Northern Ireland 2%. Based on this assumption, it is possible to test whether the observed proportion from the survey sample differ significantly from these hypothesized proportion.

Regions

	Observed N	Expected N	Residual
South East	5	8.8	-3.8
London	18	23.5	-5.5
South West	4	1.5	2.5
East of England	3	2.9	.1
West Midlands	4	1.5	2.5
Yorkshire	3	.5	2.5
North West	2	2.9	-.9
North East	1	1.5	-.5
Scotland	2	3.4	-1.4
Wales	5	.5	4.5
Total	47		

Test Statistics

	Regions
Chi-Square	67.132[a]
df	9
Asymp. Sig.	.000

Test Statistics

	Regions
Chi-Square	67.132[a]
df	9
Asymp. Sig.	.000

a. 8 cells (80.0%) have expected frequencies less than 5. The minimum expected cell frequency is .5.

These results show that the regional composition in survey sample does not differ significantly from the hypothesized values supplied (p = .000).

10.3 Appendix III: List of contacted venture capital funds

	Name of VC Fund	Contacted	Known response
1	Abingworth Management Ltd	x	x
2	AFM Limited	x	x
3	Amadeus Seed Fund	x	
4	Angle	x	
5	Avlar BioVentures Limited	x	x
6	Biofusion/ Fusion IP	x	
7	Capital Fund/YFM	x	
8	Carbon Trust	x	
9	Catapult	x	
10	Close Ventures/Albion Ventures		
11	Cre8Ventures	x	x
12	Dawn Ventures	x	
13	Eden Ventures	x	x
14	Enterprise Ventures	x	x
15	E-Synergy	x	
16	Exomedica		
17	Finance South East	x	x
18	Finance Wales	x	x
19	Hafren Ventures	x	x
20	Imperial Innovations	x	
21	Index	x	x
22	Invest Northern Ireland	x	
23	IP Group	x	
24	IPSO Ventures		
25	Liverpool Seed Fund	x	
26	London Tech Fund	x	x
27	Mercia Technology Fund	x	
28	Midven	x	
29	MMC		
30	MTI/UMIP	x	
31	NESTA	x	x
32	North West Equity Fund	x	
33	NorthStar	x	x
34	NW Brown/IQ Capital	x	
35	Oxford Capital Partners	x	
36	Oxford Technology Management Ltd		
37	Partnership Fund/YFM	x	x
38	Partnerships UK	x	x
39	Pentech Fund II	x	
40	Questor now Spark	x	
41	Seraphim/GLE/YFM	x	x
42	Sigma Technology Management	x	x
43	South East Growth Fund	x	x

44	South West Ventures/YFM	x	
45	South Yorkshire/YFM	x	
46	TTP Ventures	x	x
47	Wales Fund Managers Limited/Excalibur	x	
48	WME	x	x

10.4 Appendix IV: Survey questionnaire

1 Have any of the following bodies invested in your fund? (select all that apply)

Regional Development Agency	☐
European Union	☐
University	☐
Government Department	☐
Devolved Administration	☐
Regional Authority	☐
Other public body (please specify)	☐

2 If yes, what proportion of the funds under management do they account for?

100%	☐
75-99%	☐
50-74%	☐
25-49%	☐
under 25%	☐

3 What is the size of the fund (total assets under management)?

0-£5m	☐
£6m-£10m	☐
£11m-£20m	☐
£21m-£30m	☐
£31m-£40m	☐
£41m-£50m	☐
£51m-£100m	☐
£100m+	☐

4 In which region is the fund based?

Region - (drop down list of regions)

5 In which industry sector do you prefer to invest? (select all that apply)

Biotechnology	☐
Business product and services	☐
Computer and peripherals	☐
Consumer products and services	☐
Electronics/instrumentation	☐
Financial services	☐
Healthcare services	☐
Industry/energy	☐
IT services	☐
Media and entertainment	☐
Medical devices and equipment	☐
Networking and equipment	☐
Retail/distribution	☐
Semiconductors	☐
Software	☐
Telecommunication	☐

6 What proportion of your portfolio companies generated sales revenue at the time of your initial investment?

7 What proportion of your deals are co-investment deals (if applicable)

8 What proportion of your co-investment deals are made with

Private VC fund	
Public (publicly backed) VC fund	
Bank Loan	
Loan Fund	
R&D Grant	

9 What is your preferred stage of investment? (select all that apply)

Seed	
Start-up	
Early growth	
Late growth	
Expansion	
Other	

10 How often do you interact with the following bodies ?
(indicate the frequency of your contact face-to-face, telephone or email)
(drop down menu: never; hardly ever - once a year at most; occasionally – a few times a year; regularly – once a month; often – more than once a month; very frequently – at least once a week)

Your portfolio companies
Companies outside your portfolio
Other private venture capital funds (within your region)
Other private venture capital funds (outside your region)
Other publicly backed venture capital funds (within your region)
Other publicly backed venture capital funds (outside your region)
Business Angel networks (within your region)
Business Angel networks (outside your region)
Business Angel individuals
Banks
Universities with no flexible IP policy
Universities with flexible IP policy
Regional R&D institutes (if not universities)
RDAs (when applicable)
Other public regional bodies (e.g. endowments, councils etc)
Regional authorities
Law companies
Specialists (e.g. experts in a particular technology)
Community organisations and charities
Managers of technology parks or incubators
Companies based in technology parks or incubators
IP protection bodies

11 How often do you participate in the following networking events?

Investment forums organised by private bodies
Investment forums organised by public bodies
Networking events organised by private bodies
Networking events organised by public bodies
Internet forums and blogs

12 What proportion of your deals come from the following sources?

Other private VC funds	
Other public (publicly backed) VC funds	
Business Angel networks	
Personal business contact	
The entrepreneur approaches you directly	

13 Select the top 3 strengths of a business opportunity that normally motivates your investment

Management team expertise	
Business model scalability	
Great products/services- USP	
Defensible I.P.	
Customers and market potential	
Financial track record	
Remarkable value proposition	

14 Do you hold any advisory position within a public organisation?

15 If not, have you ever been approached by a public body to take such position?

16 If you have been approached to take such position but you decided not to accept it, what was the main reason of your decision?

17 Do you hold any position in an private association or network?

18 Are you on the boards of any economic development bodies?

19 How long have you lived/worked in the region?

20 How long have you worked in your present position?

The information you report in the survey is handled in a completely confidential process, stored and analyzed in an anonymous fashion, and will be used exclusively for research purposes. However, it will be very useful if you could provide us with the name of your company and your job title (optional)

Job Title:	
Company:	
Address:	
City/Town:	
Postal Code:	