



The role of venture capitalists in the regional innovation ecosystem: a comparison of networking patterns between private and publicly backed venture capital funds

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Abstract This paper empirically examines the development of social networks among venture capitalists and other professionals of the regional innovation ecosystem. Using an online survey of venture capitalists, the article considers their networking behaviour, focusing particularly on the distinction between those employed by private and those employed by publicly backed venture capital funds, and on the composition and spatial search of their networks. It investigates whether the frequency of interaction between venture capitalists and other members of the innovation ecosystem is associated with the nature of the venture capital funds. The paper provides the first detailed investigation of the relationship between different types of venture capitalists and other players of the innovation ecosystem such as universities incubators, research institutes, and business support organisations. The results show that there are distinctive differences within the two seemingly similar professional groups (private and public venture capitalists), and public dependence of the venture capital fund is strongly and significantly associated with higher volumes of interactions. The more publicly dependent a fund is, the more it interacts with other players of the innovation system. This finding has important implications for both academics and practitioners and suggests that publicly backed funds have a wider role to play in mobilising the different players of the regional innovation ecosystem.

Keywords Venture capital · Networks · Publicly policy · Regional development

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1 Introduction

A new generation of regions has emerged throughout the '90s to meet the challenges of knowledge-based development and globalisation. These have variously been labelled technology districts, innovative clusters and agglomeration economies (Porter 1990, 1994, 1996, 1998, 2000a, b), learning regions, regional and technological innovation systems (Cooke and Morgan 1994, 1998; Florida 1995; Lundvall 1996, Landabaso et al. 2001; Nielsen and Lundvall 2003; Bergek et al. 2008). These different explanatory schemes were formed based on theories on innovating by networking (e.g. Cooke and Morgan 1994; Landabaso et al. 2001; Morgan and Nauwelaers 1999; Oughton et al. 1999). The institutional framework of such systems 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 (Cooke and Morgan 1998). Bergek et al. (2008) describes technological innovation systems as entities that may include not only firms along the whole value chain (including those up- and downstream), universities and research institutes, but also public bodies, influential interest organizations (e.g. industry associations and non-commercial organizations), venture capitalists, organizations deciding on standards, etc. These are systems that combine learning with upstream and downstream innovation capability and thus warrant the designation regional innovation systems (Cooke and Morgan 1998).

Lundvall (2001) suggests that interactive learning is crucial for innovation, while more frequent interaction promotes innovation by facilitating the acquisition of tacit knowledge through learning. Private intermediaries like venture capitalists, management accountants, specialised law firms and consultants cohabit the same place, facilitating systemic interactions (Saxenian and Sabel 2008). These new or strengthened connections between venture capital and the regional innovation ecosystem provide the basis for subsequent efforts to form innovative firms. Cooke (2001a, b) argues that regions with vibrant innovation systems are depended on public research funds for basic scientific research, but exploitation and commercialisation of scientific findings is looked after by venture capitalists, corporate venturing arms of large firms, media or ICT firms, business angels, patent lawyers, specialist corporate lawyers, merchant banks, consultants and accountants.

There is an emerging consensus that venture capital has become a key component of “new economy innovation systems” formed by highly dynamic sets of interrelationships between venture capitalists, market conditions and new firm incubators (Cooke 2001a, b; Rosenberg 2002; Pinch and Sunley 2009). Cooke (2001a, b) describes venture capital funds as the key drivers of the new economy systems. In the venture capital community, 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; Lutz et al. 2013). 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). Organizational theorists have generally proposed that seed-stage investors rely on social relationships to select which ventures to fund (e.g. Venkataraman 1997). In particular, organization scholars have argued that two different mechanisms—information transfer through social ties and social obligation—influence investors’ decisions (Shane and Cable 2002).

Despite the theoretical importance of social networks in regional development, the networking behaviour of venture capitalists within the regional innovation ecosystem still remains quite obscure. Kenney and Florida (2000) argue, for example, that venture capitalists 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). 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.

Reflecting the importance of venture capital in both innovation policy, facilitating the commercialization of the science base, and entrepreneurship policy, facilitating the emergence of high-growth businesses, national and state/regional governments have established several schemes in support of the venture capital industry (Sunley et al. 2005). Government schemes in support of the VC industry are intended to improve business innovation and growth, and close potential funding gaps, particularly for small high-technology start-ups (Sunley et al. 2005) or in particular regions (Mason and Harrison 2002; Mason and Pierrakis 2013). Such government-backed schemes¹ aimed in leveraging private money (Sunley et al. 2005; Lerner 2002), stimulating regional entrepreneurial activity (Morgan and Nauwelaers 1999) and generating R&D spill-overs (Lerner 2002). The attempts to stimulate the supply of new sources of finance have followed different approaches, from ensuring that each region has access to regional-based VC funds to trying to demonstrate that investors in early stage funds can make robust returns, thereby promoting the private sector venture capital industry (Mason and Harrison 2003). Cooke et al. (2002) point 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.

While the proliferation of public VC schemes over the last decade has been rapid, very little has been shown to date regarding their efficacy as institutions in the entrepreneurial and innovation ecosystem and policy makers have struggle to determine how, and if, these public VC schemes should be further supported or encouraged. More particularly, existing evaluations of the schemes concerned with the financial performance of the funds (NAO 2009) show a substantially lower Internal Rate of Return (IRR) of publicly backed funds than the IRR reported by private funds. Other evaluations of the schemes show that publicly backed funds had a very marginal impact on financial performance of the portfolio companies (Nightingale et al. 2009) and a negative association with patent creation (Pierrakis and Saridakis 2017). However, Mason and Pierrakis (2013) find that such government schemes have strong regional impact on the entrepreneurial ecosystem as they significantly increase the supply of VC finance available to local SMEs. In this paper, we argue that this increase is also complimented by increased levels of networking activity—an essential component of a functional innovation system—and this activity is not restricted to VC funds and local SMEs alone, but spills over to other bodies of the regional innovation ecosystem such as universities incubators, research institutes, and business support organisations, thus increasing the exposure of these bodies to VC investors, which would have been limited in the absence of these schemes.

In particular, this paper seeks to explore and conceptualise the role of social networks in regional innovation ecosystem formation paying particular attention to the role of VCs as nodes within and across these networks. Being able to identify how VCs interact will allow

¹ Public venture capital initiatives 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).

us to speculate in more detail on the role of VCs as connectors and boundary spanners within networks. Our objective is to shed light on the role of the nature of different types of VCs (private or public) in mobilising the regional innovation ecosystem. Our work fosters integrating the venture capital literature with that on regional innovation ecosystems and supports better understanding of the way that VCs operate. The outcomes of this study are expected to provide policy makers and regional economy scholars with a better understanding of the role of publicly backed VC funds within the regional innovation ecosystem. To this end, using information from the respondents of 50 venture capitalists to an online survey, it is possible to empirically examine the networking behaviour of public and private VCs within the regional innovation ecosystem. Specifically, we identify public funds as funds that raised their majority of their assets from public bodies and private funds as funds that raised all of their assets from private Limited Partners (LPs). Funds that raised a minority of their assets from public bodies are termed co-investment funds.

Our results suggest 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 (Mason 1987, 2007; Mason and Harrison 2002; Martin 1992; Martin et al. 2005, Mason and Pierrakis 2013), but also relates to the ecology of interactions between venture capitalists and other players of the regional innovation ecosystem. Importantly, we find that public funds interact with other players of the regional innovation ecosystem to a much greater extent than private funds do. This paper investigates whether this really matters and if so why.

The remainder of the paper is organized as follows: Sect. 2 discusses the conceptual framework and the literature and uses the theory to derive the hypotheses. Section 3 discusses the data and methodology used in the paper. Section 4 presents the results, and Sect. 5 presents the conclusions and future directions for further research in this area.

2 Theoretical context and hypotheses formation

2.1 Networks, agency theory and information asymmetries

The agency theory has often been used to analyse the relationship between venture capitalists and portfolio companies (e.g. Sapienza and Gupta 1994; Lerner 1995; Sorenson and Stuart 2001; Lutz et al. 2013). 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 2003). 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). According to Shane and Cable (2002), the entrepreneurs are reluctant to fully disclose information to potential investors because such disclosure will make it easier for other people to pursue the opportunity.

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. 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). 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” (or “private 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). 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.

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). Therefore, it is expected that such relationships are formed between venture capitalists and different sources of knowledge production (universities, research institutions, and other intermediary organisations) and both large and small firms (Cooke 2003). Broader, better and longer relationships may increase the information available to investors and thus, reduce risk and monitoring costs (see Storey 1994).

2.2 Cost theory and geographical proximity

The investment decision of the venture capital fund can be broadly explained by the transaction cost theory (Williamson 1975). Costs related to identifying investment opportunities and monitoring portfolio companies are associated with geographical proximity. Interactions costs are likely to increase with increasing journey time. In fact, the importance of 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).

Previous work by Powell et al. (2002) examine the spatial concentration of ideas and money in the biotech sector and 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 argue 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, 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 (Wiltbank 2009; Fritsch and Schilder 2008; Mueller et al. 2012). However, to mitigate the inherited risks of distance-investing, Mäkelä and Maula (2008) emphasise the role of local investors in facilitating cross border investments. 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, it is anticipated that there will be stronger linkages and interactions with actors within rather than outside the region in which the funds are based.

Following an established definition proposed by Gulati et al. (2000), wherein an organisation's network is described as its set of relations, both horizontal and vertical, with other strategically significant actors, we define internal networks as internal ties within the Entrepreneurial Finance Community (e.g. other venture capital funds, business angels etc.) and external networks as external ties with the Knowledge Creation Community (e.g. universities, R&D institutes etc.) and the Business Support Community (IP protection bodies, law firms etc.). Therefore, our conceptual framework builds on established notions in literature on venture capitals and networks and the way they complement each other (see Fig. 1).

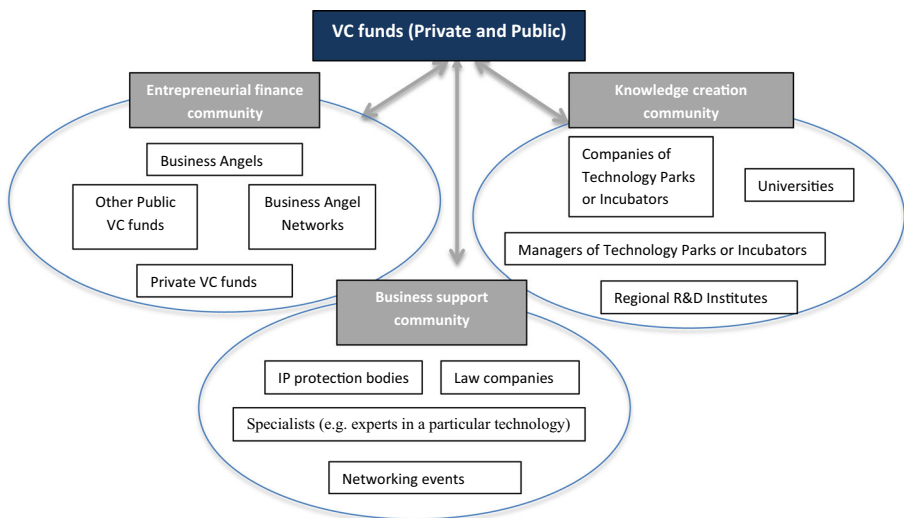


Fig. 1 Networking framework between VC funds and the regional innovation ecosystem

2.3 Public policy in fostering the VC industry

Successive UK Governments have introduced several schemes in support of venture capital finance including the, Early Growth Funds (EGFs), Regional Venture Capital Funds (RVCFs), University Challenge Seed Funds (UCSFs) and the Enterprise Capital Funds (ECFs). Various evaluations of the Government venture capital schemes have highlighted that UK 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, such funds have had only a marginal impact on business performance (Nightingale et al. 2009). Buzzacchi et al. (2013) also found that higher public stakes are significantly correlated with a lower incidence of write-offs and a longer duration for their investments. Nevertheless, 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 (Mason and Pierrakis 2013).

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 (2001, 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 that the limited supply of informed venture capitalists, rather than the availability of financial capital, is the scarce factor in launching innovative firms. This has direct implications to the creation and management of the UK publicly backed funds which are all relatively young. The design of these funds reflected a fundamental approach to leveraging private money and investing alongside private investors. It was hoped that this in turn, would improve the investment skills of the publicly backed fund and build their track record. Therefore, it is expected that publicly backed funds in order to achieve this objective, will exhibit a high frequency of interaction with other bodies of the Entrepreneurial Finance community, including private venture capital funds and business angels, perhaps much higher than those from private funds, which operate independently from governmental objectives. Hence, we hypothesise that:

H1 Venture capitalists employed by public VC funds exhibit higher frequency of interaction with the Entrepreneurial Finance community bodies than venture capitalists employed by private VC funds.

Schäfer and Schilder (2009) examined the interaction behaviours of VC funds in the case of Germany and suggested that public sector venture capital funds have a fairly similar interaction pattern with their portfolio companies to that of the bank subsidiaries. Such funds exhibit a quite high frequency of consulting in some areas (see e.g. accounting, controlling, strategic problems and financing) but have significantly less face to face contacts with their portfolio companies compared with the private VC funds. This suggests that the public equity suppliers offer only a reduced choice of smart capital services. In fact, the capabilities of public sector fund managers are 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) (Pierrakis and Westlake 2009). Despite their commitment to act as commercial funds, various scholars (Mason and Harrison 2003;

Kanniainen and Keuschnigg 2004; Schäfer and Schilder 2009) suggest there is a lack of venture-capital skills in publicly backed venture capital funds, to enable effective fund management. According to Munari 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 venture capitalists due to their lack of experience and skills. In order to compensate for the lack of skills and experience necessarily to manage the day to day operation of the fund, it is expected that publicly backed VCs investment managers, will seek more actively support from the Business Support community such as patent attorneys, specialised experts, lawyers etc. compared with their counterparts from the private sector. WE therefore hypothesise that:

H2 Venture capitalists employed by public VC funds exhibit higher frequency of interaction with the Business Support community organisations than venture capitalists employed by private VC funds.

Another reason that publicly backed VCs may establish closer links with other players of the regional innovation system is that publicly backed venture capital funds often have soft objectives e.g. to invest in university spin offs, in deprived areas or in specific geographical areas (NAO 2009). It is expected 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, we argue that professionals from publicly backed funds have established active communication and networking with the Knowledge Creation community that includes local universities, science parks and R&D institutes, and they appear to be more interactive than their counterparts from the private sector. Hence:

H3 Venture capitalists employed by public VC funds exhibit higher frequency of interaction with the Knowledge Creation community organisations than venture capitalists employed by private VC funds.

3 Data and statistical framework

3.1 Sample

The data collected for this study included responses to a questionnaire from 50 different venture capitalists (senior and middle level managers), carried out between June and July 2009. The venture capitalists were geographically dispersed across the UK and in a variety of industries. In order to minimise sample bias, each contacted venture capitalist was asked to fill out the questionnaire for the fund that he or she was most heavily involved with (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.

The questionnaire was sent out via personalised emails in an electronic format. Self-report online survey was deemed the most appropriate way to collect the required data. Questions were related to the following areas: (1) Type of Limited Partners (RDAs, EU, Universities, Government etc.) and proportion of investments into the fund; (2) Fund characteristics (size of the fund, stage, industry and geographical base); (3) Type of investments (proportion of investments made to pre-revenue companies) and frequency of interaction with a number of bodies inside and outside the region. Such interaction may

include site visits, telephone calls, email exchanges or meeting. Number of years the respondent working for the VC fund and number of years living in the region.

In order to minimise any potential common method bias which can be caused by the “Common Rater Effect” which refers to any artifactual covariance between the predictor and criterion variable produced by the fact that the respondent providing the measure of these variables is the same (see Podsakoff et al. 2003), we separated the measurement of the predictor and criterion variables. This was possible by grouping into one section of the survey all the questions related to the fund characteristics and into another section all the questions related to their personal networking behaviour. In addition, we allowed for full anonymity of the responders and informed them that any information they report in the survey will be handled in a completely confidential process, stored and analysed in an anonymous fashion, and will be used exclusively for research purposes.

Initially, all early stage venture capital funds operating in the UK were identified through desk research (48 in total). These funds were specialised in high technology and innovative ventures and were members of the British Venture Capital Association (BVCA). 43 of those funds 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 and early growth stage. Using desk research (internet, brochures and the BVCA directory) 309 individual venture capitalists (investment managers or investment directors) that worked in these 43 early stage venture capital funds were identified. Correct and update details were acquired for 270 of them. The questionnaire was sent to all investment managers (270) of all the UK based early stage VC funds (43).

The response rate of completed questionnaires is 19% (50 fully completed questionnaires). Due to the sensitivity of the industry the questionnaire was completed on an anonymous basis however, participants were invited to reveal 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 (47% of contacted funds). Consequently, the response rate of 19% of the venture capitalists that responded represents at least 47% of the venture capital funds that were contacted. Table 7 in Appendix provides information about the survey sample.

In order to test for any bias in the respondents that answered the survey and those that did not, it is important to ensure the integrity of the responses. First, 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). Second, to check for nonresponse bias we compared the characteristics of early responders with late responders based on the date of the survey completion—e.g. Lindner et al. (2001) suggest that late responders are similar to nonrespondents and thus, late responders can be used as a proxy for nonrespondents. Overall, we find no significant differences among internal and external group of contacts, types of funds and fund characteristics among the two groups suggesting in turn that there are no differences between responders and nonresponders.

3.2 Statistical methodology and variables used

The type of interactions between venture capitalists and other players of the innovation system are grouped into three categories. One category focuses on the interactions of the venture capitalists within the Entrepreneurial Finance community, which includes,

portfolio firms, firms seeking equity finance, public and private venture capital funds, business angel networks and individuals, banks and investment forums organised by private and public bodies. The second category examines the interactions between the venture capitalists with players of the Knowledge Creation community such as universities, other research institutes, managers of incubators, companies based on incubators., and finally a third category which includes players of the Business Support community such as RDAs, regional authorities, specialists, law companies and IP bodies.

The three dependent variables call for quantitative answers by survey respondents and are measured in an ordinal scale. Specifically, venture capitalists were asked to state the frequency of interaction with various bodies from the two groups, by choosing one of the following options: (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. This interaction may include site visits, telephone calls, email exchanges or meetings. Hence, the frequency of interaction is captured in our analysis by each of the above dependent variables. The dependent variables are categorical and ordered and modelled as a function of a set of explanatory variables,

The frequency of interaction between the venture capitalists and various bodies is regressed on a set of key and other explanatory variables to minimise issues related to unobserved heterogeneity, omitted variable bias and causal inference problems.² In particular, all funds that took part in the survey were grouped into three categories, according to the proportion of public money that they received:

- The first group includes funds that received more than 50% of their assets from public bodies (*public funds*).
- The second group consists of funds that receive between 1 and 49% of their assets from public bodies (*co-investment funds*).
- The final group comprises funds that are solely private and did not receive any finance from a public organisation (*private 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). 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% of them were employed by a solely private VC fund.

Often size is associated positively with both under- writer and venture capital reputations (Lin 1996) which may result to an increased demand for meetings with co-investors or companies. It is also expected that the larger the fund the more investment managers would employ which may result to more time allowance for networking and interaction. In order to control for this possibility, the size of fund has been used in our analysis as a control variable. The fund size variable is a categorical variable which takes values from 1 to 4 as follows: 1 = <£11 m; 2 = £11 m–£30 m; 3 = £31 m–£50 m; 4 = £51 m–£150 m. Additionally, Sapienza and Amason (1993) found that the extent 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. The segment of the investments market that this paper investigates,

² We recognise, however, that it is unlikely that we are able to effectively control for all the variables associated with social networks and the extent of interaction among different players, as some are probably unobserved.

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. A variable that captures the proportion of portfolio companies that generate revenue has been used as a proxy to control for the development stage of the investee companies.

Finally we control for both time the VCs is employed by the fund and time the VCs has spent in the region. In particular, specific characteristics of venture capitalists may be used as predictions of their social behaviour. It seems plausible that the better-networked VCs are also the older and more experienced VCs (Hochberg et al. 2007). To rule out the possibility that our measures of interaction are influenced by experience, our models explicitly control for two dimensions of experience, time that the professional has spent within the company and the number of years that he or she lived in this particular region. 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). Finally, 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.

Turning to the estimation techniques, an ordered probit analysis is used to explore the determinants of the extent of interaction between the venture capital and the innovation community. The ordered probit model is a generalization of the binary response model and because there are 6 alternatives with 5 thresholds (μ), we can write this as:

$$y_i^* = b'X_i + u_i \quad (1)$$

where y_i^* represented the latent variable, denoting the unobserved propensity of an investor i in interacting with the Entrepreneurial Finance community, the Knowledge Creation and the Business Support community, respectively. X_i is a row vector of explanatory variables³ and u_i is assumed to be normally distributed. Each explanatory variable has a base/reference category, to which other categories are compared with.

Since there are 6 possible outcomes, a set of threshold coefficients $\{\mu_1, \dots, \mu_5$ is defined. Although y_i^* was unobserved, we observed y_i such that: $y_i = 1$ if $y_i^* \leq \mu_1$; $y_i = 2$ if $\mu_1 < y_i^* \leq \mu_2$; $y_i = 3$ if $\mu_2 < y_i^* \leq \mu_3$; $y_i = 4$ if $\mu_3 < y_i^* \leq \mu_4$; $y_i = 5$ if $\mu_4 < y_i^* \leq \mu_5$; and $y_i = 6$ if $\mu_5 < y_i^*$, where b and μ (threshold parameters) are the parameters to be estimated.⁴ The ordered probit model coefficients are estimated using maximum likelihood methods and technical details can be found at Wooldridge (2013).⁵ Although the coefficients of ordered probit cannot be interpreted directly, the sign of the coefficients shows the direction of the impact of each explanatory variable.⁶

³ We use the variance inflation factor (*vif*) approach to test for multicollinearity). The *vif* values are low—with an average value of 2.24. This suggests that multicollinearity is not an issue here.

⁴ The threshold parameters are not reported or discussed since they do not have important behavioural interpretations.

⁵ For robustness check, we also estimated the models using an Ordinary Least Squares (OLS). However, the results are found to be similar to ordered probit estimates and thus, are not reported here.

⁶ When we estimate the ordered probit models using robust standard errors to allow for heterogeneity and serial correlation across observations the conclusions are similar.

4 Results

4.1 Sample statistics

Table 1 provides information about the means of the variables capturing interactions with the finance community. Column 1 provides information for the overall sample whereas columns 2–4 show estimates for three sub-samples: Public Funds, Co-investment Funds and Private Funds. Table 1 reveals that venture capitalists interact closely with other private funds within their region on a regular basis while they tend to interact less with private funds outside their region. A similar pattern appears when looking at the frequency of interaction with the public funds. Another notable interaction partner for the VCs is Business Angels networks. Business Angels have become a prominent source of early stage finance and their importance has been widely acknowledged in recent years by various scholars (Mason and Harrison 2002, 2008). Also, Table 1 shows that the majority of venture capitalists interact more closely with Business Angel networks within their region compared to Business Angels network outside their region. Additionally, the estimated means are found to be statistically different ($p < 0.01$) among the three types of venture capital funds [with $F(2, 39) = 8.07$ for Business Angel networks within your region and $F(2,39) = 7.56$ for Business Angel networks outside your region]. Overall, Table 1 provides initial support for Hypothesis 1 as public funds interact more frequently with Business Angels and other public funds, than the private funds.

In Tables 2 and 3, we show the frequency of interaction between the VC community with the Business Support and Knowledge Creation communities. As previously noted, venture capitalists were asked to state the frequency of their interaction with various bodies including universities, R&D institutes, law companies, specialists, IP protection bodies, technology parks and incubators and networking events. Table 2 shows that on average, VCs interact less with the professionals of the Business Support community with notable exceptions, “Specialists (e.g. experts in a particular technology)” and “Law companies”. For the latter group the estimated means are found to be statistically different ($p < 0.01$) among the three types of venture capital funds [with $F(2, 40) = 5.43$]. However, Table 2 also suggests that public funds interact with the players of the Business Support community much more often than their counterparts from the private sector, providing some support for Hypothesis 2. In contrast, as shown in Table 3 venture capitalists interact with universities or regional R&D institutes only ‘occasionally. Also, companies based in technology incubators are contacted occasionally—a few times a year—by venture capitalists. Table 3 suggests that public funds interact more frequently with other players of the Knowledge Creation community, than the private funds, providing some support for Hypothesis 3.

4.2 Ordered probit analysis

We now turn to explore our hypotheses developed earlier using a multivariate framework. In this section we empirically examine the determinants of the Entrepreneurial Finance, Knowledge Creation and Business Support communities using an ordered probit estimator. The results are presented on Tables 4, 5 and 6, respectively.

Table 4 shows the estimates for the extent of interaction between venture capitalists and several bodies from the Entrepreneurial Finance community, controlling for size of funds, proportion of portfolio companies generating revenues, years that the venture capitalists

Table 1 Entrepreneurial finance community

Type of venture capital funds	All funds			Public funds			Co-investment funds			Private funds		
	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD
<i>Variables</i>												
Other private venture capital funds (within your region)	45	4.31	1.28	23	4.22	1.00	14	4.64	1.55	8	4.00	1.51
Other private venture capital funds (outside your region)	46	3.96	1.28	24	3.92	1.21	14	3.93	1.27	8	4.13	1.64
Other publicly backed venture capital funds (within your region)	44	3.48	1.13	23	3.91	0.90	14	3.00	1.24	7	3.00	1.15
Other publicly backed venture capital funds (outside your region)	44	3.18	1.19	23	3.57	1.12	13	2.69	0.85	8	2.88	1.55
Business angel networks (within your region)	47	3.70	1.10	25	4.24	1.01	14	3.29	0.91	8	2.75	0.71
Business angel networks (outside your region)	46	2.96	1.05	24	3.50	0.98	14	2.57	0.76	8	2.00	0.76
Business angel individuals	45	3.87	1.27	23	4.22	1.20	14	3.43	1.22	8	3.63	1.41

The variables 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”. The estimated means are found to be statistically different ($p < 0.01$) among the three types of venture capital funds for business angel networks within your region and business angel networks outside your region

spent in the region and in the fund. The results show that in the models of “Other private venture capital funds (within your region)”, “Other publicly backed venture capital funds (within your region)”, “Business angel networks (within your region)” and “Business angel networks (outside your region)” the coefficients of public funds are found to be positive and statistically significant. In other words, compared with private funds, public funds are found to have a higher probability of regular interactions with these networks. Interestingly, the coefficient of public funds variable is only statistically significant on the model of publicly backed venture capitalists within their regions whereas the coefficient is found to be statistically insignificant outside their region. However, public funds interact more with Business Angels networks both within and outside the region than private funds. Overall, there is a clear pattern of the ecology of interaction between different types of

Table 2 Business support community

Type of venture capital funds	All funds			Public funds			Co-investment funds			Private funds		
	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD
<i>Variables</i>												
Regional authorities	43	2.12	1.00	22	2.23	0.97	13	2.15	0.99	8	1.75	1.16
Law companies	47	4.3	1.16	25	4.56	1.08	14	4.43	1.16	8	3.25	0.89
Specialists (e.g. experts in a particular technology)	47	4.15	1.18	25	4.52	1.08	14	3.93	0.92	8	3.38	1.51
IP protection bodies	46	2.72	1.22	24	2.96	1.37	14	2.71	0.91	8	2.00	1.07
Networking events organised by private bodies	47	3.66	1.07	25	3.68	1.21	14	3.71	0.99	8	3.50	0.76
Networking events organised by public bodies	47	3.91	0.95	25	4.2	1.08	14	3.71	0.47	8	3.38	0.92

The variables 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”. For “Law companies” group, the estimated means are found to be statistically different ($p < 0.01$) among the three types of venture capital funds

venture capitalists and the Entrepreneurial Finance community. Professionals from public funds interact more often with professionals from the same region compared with their private counterparts. Also, public funds interact significantly more often with Business Angel networks than private funds do. Hence, the results provide further support of Hypotheses 1.

Turning to the control variables, we also observe some interesting results. The size controls coefficients provide some indication that as the size of the fund increases the probability of interaction initially increases; but as the fund grows more this association becomes either negative or insignificant. The coefficients for the revenue variable are generally negative and statistically 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 (see for example, Sapienza and Amason 1993). As Sapienza and Amason (1993) 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. In most models the coefficients for the variables “years in region” and “years in company” are found to be statistically insignificant.

Tables 5 and 6 provide the results for the Business Support and Knowledge Creation communities. Overall, the results suggest that public funds have a positive and statistically significant association with most organisations of the two communities. For example, in Table 5 we find that venture capitalists working for publicly backed funds interact with law

Table 3 Knowledge creation community

Type of venture capital funds	All funds			Public funds			Co-investment funds			Private funds		
	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD
<i>Variables</i>												
Universities with no flexible IP policy	47	2.81	1.04	25	2.92	1.15	14	2.86	0.77	8	2.38	1.06
Universities with flexible IP policy	47	3.11	1.07	25	3.20	1.15	14	3.21	0.97	8	2.63	0.92
Regional R&D institutes (if not universities)	47	2.83	1.31	25	3.12	1.33	14	2.71	1.14	8	2.13	1.36
Managers of technology parks or incubators	47	2.85	1.08	25	3.28	0.89	14	2.57	0.65	8	2.00	1.60
Companies based in technology parks or incubators	46	3.41	1.11	25	3.76	1.09	13	3.08	0.49	8	2.88	1.55

The variables 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”

companies,⁷ specialists, managers of technology parks or incubators, IP protection bodies and networking events organised by private bodies much more often than their counterparts from the private sector. Turning into Table 6, we also find that the coefficients for the 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. A similar picture emerges when looking at the extent of interaction with regional R&D institutes, for example. In most of these cases, we also report a positive and statistically significant coefficient for the co-investment funds variable. Hence, the results do provide additional support for Hypotheses 2 and 3.

Looking at the control variables, we find that the size of funds has a weak association with the extent of interaction with the Knowledge Creation community whereas the variable revenue is consistently negative and in some cases statistically significant. Generally, the time that a venture capitalist has spent in the fund has a positive association with the Knowledge Creation community interaction suggesting that it takes time for a professional to establish contacts with these communities. Alternatively, and more likely, the positive coefficient of this variable 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. Finally the variable “years in region” is generally found to carry a statistically insignificant coefficient.

⁷ 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 addition, public funds may interact more often with specialists than private funds.

Table 4 Ordered probit estimates between VC funds and the entrepreneurial finance community

Dependent variable: extent of interaction with the following	(1)	(2)	(3)	(4)	(5)	(6)
	Other private VC funds (within your region)	Other private VC funds (outside your region)	Other public VC funds (within your region)	Other public VC funds (outside your region)	Business angel networks (within your region)	Business angel networks (outside your region)
	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)
Type of funds (private funds)						
Public funds	1.582** (0.621)	0.462 (0.547)	2.133*** (0.636)	0.798 (0.579)	1.569** (0.618)	1.716*** (0.619)
Co-investment funds	1.985*** (0.667)	0.402 (0.582)	0.195 (0.597)	-0.419 (0.617)	0.295 (0.617)	0.604 (0.609)
Size of funds (<£11 m)						
£11 m–£30 m	0.498 (0.684)	0.277 (0.654)	2.446*** (0.784)	1.741** (0.733)	-0.026 (0.666)	0.471 (0.690)
£31 m–£50 m	0.410 (0.668)	0.494 (0.638)	1.372** (0.695)	0.944 (0.699)	-1.302* (0.680)	0.328 (0.647)
£51 m–£151 m	-1.012 (0.656)	-0.236 (0.615)	0.663 (0.657)	1.118* (0.661)	-0.418 (0.632)	0.100 (0.626)
Revenue (0–100%)	-0.023*** (0.007)	-0.0093 (0.006)	-0.023*** (0.007)	-0.012* (0.007)	-0.001 (0.007)	0.001 (0.006)
Years in region (0–56)	0.0099 (0.015)	-0.011 (0.014)	0.042** (0.017)	-0.016 (0.017)	-0.016 (0.015)	-0.022 (0.016)
Year in company (1–10)	-0.023 (0.081)	-0.0065 (0.077)	0.030 (0.077)	0.089 (0.080)	0.038 (0.078)	0.013 (0.078)
LR chi2(8)	22.51***	7.49	30.72***	17.14**	20.84***	17.83**
Log likelihood	-47.87	-59.07	-42.88	-50.11	-46.73	-46.73
Observations	38	39	38	37	40	39

Standard errors in parentheses

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

5 Conclusions and discussion

This article empirically examined the frequency of interaction between venture capitalists and other players of the innovation ecosystem that belong to the Entrepreneurial Finance, Business Support and Knowledge Creation communities. Our results indicated that the volume of interaction is strongly associated with the nature of the fund. Specifically, venture capitalists employed by a publicly backed fund, interact with the other bodies from the Entrepreneurial Finance community more often than the private venture capitalists do and are more engaged with both the Business Support and the Knowledge Creation community. Additionally, 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.

Table 5 Ordered probit estimates between VC funds and the business support community

Dependent variable: extent of interaction with the following	(1) Law companies	(2) Specialists (e.g. experts in particular technology)	(3) IP protection bodies	(4) Networking events (organised by private bodies)	(5) Networking events (organised by public bodies)
	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)
Type of funds (private funds)					
Public funds	1.814*** (0.598)	1.236** (0.577)	1.670*** (0.612)	0.796 (0.583)	1.048* (0.590)
Co-investment funds	1.338** (0.619)	0.534 (0.612)	1.197* (0.623)	0.589 (0.609)	-0.046 (0.613)
Size of funds (<£11 m)					
£11 m–£30 m	1.133* (0.683)	0.540 (0.680)	0.133 (0.666)	-1.333* (0.713)	-0.481 (0.685)
£31 m–£50 m	0.0451 (0.642)	0.534 (0.673)	-0.279 (0.645)	-0.688 (0.666)	-0.435 (0.674)
£51 m–£151 m	0.660 (0.629)	0.508 (0.643)	0.375 (0.624)	-0.008 (0.630)	-0.176 (0.633)
Revenue (0–100%)	0.001 (0.006)	-0.015** (0.006)	-0.009 (0.006)	-0.009 (0.007)	-0.016** (0.007)
Years in region (0–56)	0.018 (0.014)	-0.008 (0.014)	0.002 (0.015)	0.018 (0.015)	0.010 (0.015)
Year in company (1–10)	0.015 (0.076)	0.008 (0.074)	0.078 (0.077)	0.011 (0.078)	0.162* (0.083)
LR chi2(8)	15.99**	14.21*	12.81	13.25	13.31
Log likelihood	-52.29	-59.07	-50.13	-49.39	-43.82
Observations	40	40	39	40	40

Standard errors in parentheses

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

From a practical perspective, the findings of this paper suggest 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 it extends to the ecology of interactions between venture capitalists and other players of the regional innovation ecosystem. This result may be explained by the fact that professionals from the publicly backed funds are less experienced and also have the—sometime implied—objective to interact with other players of the regional innovation ecosystem in order to foster the entrepreneurial and innovation community. Another explanation could be related to the fact that investments in early stage companies require more interactions compared with investments made in late stage (Sapienza and Amason 1993). So if public funds invest more often in early stage companies than private funds, they may interact more often with the sources of investable opportunities such as universities and science parks. However, in this paper we included a ‘revenue’ variable as a proxy for company stage in order to control for such a possibility. The results remained the same after controlling for the

Table 6 Ordered probit estimates between VC funds and the knowledge creation community

Dependent variable: extent of interaction with the following	(1) Universities with no flexible IP policy Coef. (SE)	(2) Universities with flexible IP policy Coef. (SE)	(3) Managers of technology parks and incubators Coef. (SE)	(4) Companies based in technology parks and incubators Coef. (SE)	(5) Regional R&D institutes Coef. (SE)
Type of funds (private funds)					
Public funds	1.166* (0.598)	1.340** (0.592)	1.739*** (0.630)	1.263** (0.621)	2.041*** (0.657)
Co-investment funds	1.185* (0.643)	1.313** (0.634)	0.685 (0.650)	0.335 (0.646)	1.408** (0.690)
Size of funds (<£11 m)					
£11 m–£30 m	–0.465 (0.687)	0.065 (0.666)	0.370 (0.676)	–0.547 (0.684)	0.709 (0.698)
£31 m–£50 m	–0.141 (0.660)	–0.240 (0.647)	0.049 (0.662)	–0.054 (0.667)	0.423 (0.695)
£51 m–£151 m	–0.516 (0.646)	–0.591 (0.635)	0.345 (0.639)	–0.118 (0.642)	0.463 (0.665)
Revenue (0–100%)	–0.018*** (0.006)	–0.018*** (0.006)	–0.010 (0.006)	–0.015** (0.007)	–0.028*** (0.007)
Years in region (0–56)	–0.012 (0.015)	–0.010 (0.015)	–0.006 (0.015)	–0.019 (0.015)	–0.001 (0.015)
Year in company (1–10)	0.184** (0.080)	0.206** (0.082)	0.180** (0.079)	0.096 (0.079)	0.111 (0.078)
LR chi2(8)	12.63	14.08*	16.97**	15.42*	25.17***
Log likelihood	–46.57	–50.16	–48.67	–45.13	–50.34
Observations	40	40	39	40	40

Standard errors in parentheses

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

investment stage. In addition, our research shows that size of the fund and experience of the individual venture capitalists do not explain the differences in the extent of interactions observed between those investment managers employed by publicly backed and those employed by private VC funds. Additionally, publicly backed funds often have social objectives to invest in areas where private funds do not invest such as deprived areas or under-invested industries (NAO 2009). Therefore, they may allocate more time in searching for quality ventures in areas or industries where investable opportunities are scarce.

Moreover, specific social skills, such as the ability to read others accurately, make favourable first impressions, adapt to a wide range of social situations, and be persuasive, can influence the quality of interactions between entrepreneurs and venture capitalists (Baron and Markman 2004). Our study was based on self-reported data and the quality of social skills was not assessed. However, it has been assumed that professionals from publicly backed VC funds do not exhibit better social skills than those employed by the

private VC funds. In addition, cultural characteristics of an institution impose characteristic patterns of interaction on the people who make up a society, affecting who meets whom, on what terms, to perform which tasks, and with what expectation of rewards (Bowles 1998). In that sense, the extent of interaction of the VCs could be influenced by the cultural characteristics of their institution and private VCs may have a more 'selective attitude' towards who they meet and how often, compare with the public VCs.

While, Hochberg et al. (2007) found that it is the better-networked VC firms that perform the best and 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 different players of the regional innovation ecosystem to a greater extent than their private counterparts, but they experience less success, measured by the financial performance of the funds (NAO 2009), financial and innovation performance of their portfolio companies (Nightingale et al. 2009; Pierrakis and Saridakis 2017). In other words, the frequency of interaction between venture capitalists and other professionals is not correlated with greater success and the funds that interact more, are less successful than funds that interact less. The explanation of why this may be happening can be twofold.

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).

Second, higher frequency of interaction does not necessary mean that venture capitalists become aware of better opportunities than 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.

The above discussion begs the question: *If interaction does not provoke financial success on its own, does it really matter whether public VCs interact more with the regional innovation system players compared with their counterparts from the private sector?*

The answer is positive and is based on the following three observations. First, through their high levels of engagement, public VCs support 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. The aim of the public interventions in the area has been to foster the VC industry, especially in regions that lack VC investments. However, successful VC communities cannot be created overnight and in a linear order, but instead they are created through a complex puzzle of quality interactions and networks that requires significant time to be materialised and come to fruition. Publicly backed VCs have the capacity to activate the search and screening

process over a wider network of contacts within a geographical space and can deploy the extensive reach of their networks to identify and evaluate investments opportunities. Publicly backed VCs therefore play an important role in these networks of associations and significantly contribute to the generation of the dynamics that add value to regional innovation ecosystem by facilitating the generation, diffusion and absorption of new knowledge.

Second, our findings suggest that publicly backed VC funds play a greater role in mobilising the regional innovation ecosystem compared with private VC funds. Public VC funds exhibit more interaction activity and this activity appears to not be restricted to VCs and portfolio companies alone, but spills over to non-financial related organisations as well, such as universities incubators, research institutes, and business support organisations. Interaction and collaboration between public VCs with other organisations of the innovation ecosystem may increase the exposure of these organisations and the companies they support to the VC industry as a whole, thus improving the level of investment readiness of the companies and the indigenous capacity of the region to absorb VC funding by building tacit forms of local expertise.

Third, public VCs should be seen as conduits 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. Co-investment activity (investments between public and private VC funds) should be seen as a learning process for the public VCs, which will eventually acquire the same skills as their private counterparts. It is 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. Therefore, when assessing the impact of the public VC schemes, policy makers should not ignore the significant spill over effects that their activities have and their impact on regional innovation ecosystem.

Overall, there has been very little research to date on mapping and understanding the relationships between VCs and different regional organisations and how they may affect the overall innovation ecosystem. This paper provides the first detailed empirical investigation of the relationship between VCs and other players of the regional innovation ecosystem. Although it does not analyse empirical factors that may be responsible for such relationship and it collects data from VC 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. 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. In addition, 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 ecosystem.

One of the limitations of this study has been the small sample size which is a result of the reluctance of venture capitalists to participate in academic studies. Although the responses of approximately 47% of all early stage UK VC funds are represented in this study, future work should seek to achieve bigger sample sizes. Other limitations should also be kept in mind when interpreting the results of this study. 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). Furthermore, we encourage larger scale studies than the one presented here to be able to explore issues related to causality and endogeneity form potential unobserved characteristics of the private and public sector backed venture capital funds that may affect the estimated associations. Finally, a future study could connect the results of this paper to what has happened since the beginning of this decade in the fast-changing VC/Business Angels/Startup/Crowdfunding industries in the United Kingdom.

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Appendix

See Table 7.

Table 7 Survey sample

	Number	%
Total number of early stage VC funds identified	48	
Total number of early stage VC funds contacted	43	
Total number of investment managers employed by the 43 VC funds	309	
Total number of investment managers with valid contact details approached	270	
Total number of responses	52	
Total number of fully completed individual responses	50	19
Total number of known VC funds represented by the 50 individual responses	20	47

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