The effects of intra- and extra-industry networks on performance: A case of venture capital portfolio firms.

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Abstract

This study examines the influence of *intra-* and *extra-industry* networks on firm performance by using data on 1264 UK venture capital (VC) backed start-up companies. The ventures' network was operationalized by connecting together the various portfolio companies sharing the same investor. Regression results show that the venture's network has a strong impact on firm's success. Yet, whereas *extra-industry* ties are directly and positively linked to the likelihood of the venture to reach a successful exit, *intra-industry* ties exert a negative impact on companies' performances. However, interaction effects show that once a firm establishes a sufficient number of *extra-industry* ties, it is able to profit from the network in its industry of operation. Overall, these findings show that an optimal balance of ties is achieved through a diverse set of connections incorporating both *intra-* and *extra-industry* ties.

Introduction

Although a venture's network may facilitate the pursuit of new opportunities, provide access to innovative knowledge and hence enhance performance, it is increasingly recognized as not only an asset but also as potential liability that constrains the firms' operations and is costly to maintain (e.g. Baden-Fuller *et al.*, 2011; Brass *et al.,* 2004; Gargiulo and Benassi, 2000; Stam and Elfring, 2008). A better understanding of the conditions under which a venture's network enhances a firm's performance may thus require a contingency perspective in which the categorization of the networks is based on tie attributes rather than structural measures (Lorrain and White, 1971). As pointed out by various scholars (e.g. Dahlander and Frederiksen, 2011: 1002; Gulati, 1995: 645; Lavie, 2006; Maurer and Ebers, 2006), while much work has focused on the structural attributes of the firm's networks, surprisingly few studies have examined how heterogeneous ties, in particular *intra-* and *extra-industry* connections, impact the firms' success. The limited empirical evidence that exists suggests that, although networks may enhance performance of entrepreneurial firms, not all ties do so equally (Peng and Luo, 2000). Thus, identifying the contingency conditions under which particular networks enhance or constrain venture's success represents an important research agenda (Lee *et al.*, 2001).

In this paper we aim to contribute to previous network literature by studying how network capital that is embedded in the *intra-* and *extra-industry* ties of entrepreneurial ventures impacts the firm's success. In the economics and entrepreneurship literature, a network is seen as invaluable for the entrepreneur because it provides access to resources, contacts and opportunities (Ahuja, 2000; Aldrich and Martinez, 2001; Batjargal, 2003; Baum and Oliver, 1991; Birley, 1985; Bruderl and Preisendorfer, 1998; Combes, Lafourcade and Mayer, 2005; Dimov and De Clercq,

2006; Knack and Keefer, 1997; McEvily and Zaheer, 1999; Podolny and Baron, 1997; Stuart *et al.,* 1999). Networks also play a pivotal role in enabling actors to discover opportunities (Burt, 1992), perceive and exploit them (Companys and Mullen, 2007). However, some researchers highlight the cost of managing networks and propose a cost-benefit trade off associated with networks. Gargiulo and Benassi (2000) for example conclude that "like the tightrope walker who maintains balance by constant movements of his balancing pole, the successful individual or organization in today's business environment may have to continuously balance the trade-off between safe (e.g. *intra-industry*) and flexible networks (e.g. *extra-industry*)." Contributing to recent efforts to integrate this apparently opposing views we try to reconcile these perspectives (e.g., Oh *et al.*, 2004; Stam and Elfring, 2008) building on the premise that network capital has contingent value (Ahuja, 2000)[1].

Therefore we propose that optimal firm performance results from a specific balance of *intra-* and *extra-industry ties*. Since simultaneously establishing these two sets of ties may involve significant trade-offs, it is relevant to understand whether they are complementary or duplicative (Stam and Elfring, 2008). We argue that both types of network provide ventures with access to distinct resources (Geletkanycz and Hambrick, 1997), and we show that the value of such access is maximized when a firm combines the two types of ties in a certain proportion. Once the venture departs from this optimal combination of *intra-* and *extra-industry* ties, its chances of being successful drop. However, if we consider the ties separately, it appears that *extra-industry* ties are more

[1] Ahuja (2000) argues that the nature and content of the ties, the type of outcome being studied, and the broader network structure within which a tie is embedded are all likely to influence the value of a tie. We use the nature and content of the ties as a contingency.

beneficial to a firm's success than *intra-industry* connections.[2] We argue that the positive effect of *extra-industry* ties is predominantly related to the knowledge and resource diversity to which these ties give access to. On the other hand, *intra-industry* ties offer resources that the venture may already possess, and with a lack of *extra-industry* ties, the venture will not be able to take advantage of a brokerage position between the two "worlds".

Using a combination of secondary data, hand collected firm-level variables and primary sources on networks of VC-backed ventures in the United Kingdom, this research specifically examines how a firm's *intra-* and *extra-industry* VC portfolio network centrality contributes to the success of the firm. Addressing recent calls for "more complex, multidimensional models that investigate the interactions between different types of social capital conduits" (Oh *et al.*, 2004: 870), in particular differentiating between *intra-* and *extra-industry* ties (Gulati, 1995:645), we aim to identify the configuration of network ties that maximizes the contribution of networks to ventures' success.

Theory and hypotheses

Networks can be defined both as an entrepreneur's attempt to mobilize personal contacts in order to profit from entrepreneurial opportunities (Granovetter, 1985) and as a firm's effort to cooperate with others in order to obtain and sustain a competitive advantage (Peng and Luo, 2000). Brass *et al.* (2004) define a network as a set of nodes

[2] *Intra-* and *extra-industry* ties represent a measure of network composition which refers to the types of actors defined by their stable traits, features or resource endowments (Phelps, 2010; Wasserman and Faust, 1994) whereas tie strength or weakness refers to the content of the tie i.e. the extent to which the actors refer to each other.

and the ties representing some relationships, or lack of relationships, between the nodes (individuals, work units, or organizations). Network structure relates to the pattern of relationships that exist among a set of actors, while network composition refers to the types of actors defined by their stable traits, features or resource endowments (Phelps, 2010; Wasserman and Faust, 1994). The content of the relationships represented by the ties can vary widely, and it is limited only by a researcher's imagination (Brass *et al.*, 2004). Specifically, we define the network as the actual and potential resources available to a firm through its network of relationships (Nahapiet and Ghoshal, 1998) established by VC-backed ventures within the portfolio of each VC investing in the firm.

Building on recent research (e.g. Dahlander and Frederiksen, 2011; Geletkanycz and Hambrick, 1997; Stam and Elfring, 2008) we focus our attention on the ties' attributes rather than structural measures. Our focus on network attributes is based on a premise that, although prior work has examined the core discussion related to networks of entrepreneurs (e.g., McEvily and Zaheer, 1999) and the structural differences of ties (e.g. Stam and Elfring, 2008), this literature lacks systematic research differentiating the resources accessible through different types of ties, therefore acknowledging the heterogeneity of the connections. This study specifically examines two important dimensions of a firm's network: (1) *intra-industry* network ties and (2) *extra-industry* ties. Following the differentiation between "internal" and "external" social capital (Adler and Kwon, 2002), our approach builds on the notion that *intra-* and *extra-industry* ties provide a focal firm with access to distinct social capital resources, in line with Geletkanycz and Hambrick (1997) and Stam and Elfring (2008).

However, our paper departs from Geletkanycz and Hambrick (1997) and Stam and Elfring (2008) on various important dimensions. First, these authors study the impact of ties at the executives' level, rather than at the firms' level; second, their sample is related to publicly traded firms while our sample is composed of young firms operating in rapidly changing environments. Third, methodologically they assume the existence of external ties while we adopt specific and longitudinal measures that allow us to precisely identify the amount of external connections and their nature. Hence, to the best of our knowledge, this paper is the first which specifically studies the impact of *intra-* and *extra-industry* ties on entrepreneurial ventures' success.

Entrepreneurial ventures' success

In this study we look at the effect of two types of ties, *intra- and extra-industry,* on firm's success. In this section we explain how we define success.

Entrepreneurial ventures, especially in their early years, are usually cash flow negative or have very limited profits. Many VCs argue that valuing a start-up is more an art than a science but the industry agrees that the exit is the ultimate acknowledgement of the start-up market value and therefore its success. Therefore, considering that the main successful [exit] routes considered in the literature are IPOs and trade sales (Manigart and Wright, forthcoming: 56), in this paper we consider the company exit as our measure of success.

The role of *intra-* and *extra-industry* ties

Previous studies suggest that ventures with central network positions enjoy several advantages that contribute to higher performances (Brass *et al.*, 2004). Being

highly connected allows a firm to learn about new market conditions, strategies of competitors, and partnership opportunities (Powell *et al.*, 1996) and have access to alternative providers of valuable resources (Tsai, 2001). However, different ties offer different benefits and each tie has a particular trade-off between costs and benefits (Baden-Fuller *et al.*, 2011).

In rapidly changing environments, such as the one in which entrepreneurial ventures are embedded in, firms increase their performances by focusing on ties that offer non-duplicative resources in order to gain new information and knowledge (Christensen and Raynor, 2003; Duysters, 1996). For instance, biotechnology start-ups with networks providing access to diverse information have higher revenue growth (Baum et al., 2000). *Cosmopolitans* - entities that are connected with different networks or industries - are more likely to innovate, and are therefore potentially more successful (Dahlander and Frederiksen, 2011). Furthermore, resource heterogeneity accessed through connections is an important source of success (Hagedoorn and Schakenraad, 1994; Penrose, 1959; Prahalad and Hamel, 1990; Ring and van de Ven, 1994).

In this light we posit that *extra-industry* ties, connections that span outside the main industry of operations of the focal firm, lead entrepreneurial ventures to succeed not only because they offer access to a diverse knowledge base and heterogeneous resources, but also because they help the firm to gain power and potential for brokerage opportunities. Considering that ventures should develop new routines, competencies, and technologies (Stam and Elfring, 2008) and that *extra-industry* ties facilitate access to complementary resources that are not available within the industry boundaries (Stam and Elgring, 2008), and therefore stimulate exposure to a diversity of approaches, perspectives, and ideas that are not well established in the focal industry (Hargadon,

2002), allowing the focal firm to "bring together new combinations of productive factors" (Low and Abrahamson, 1997: 443), *extra-industry* ties are very valuable for new ventures. In sum, *extra-industry* ties are more likely to lead the firm to success by functioning as a scanning device that allow entrepreneurial firms to detect new trends and asymmetries in a market faster than firms lacking such connections.

In addition, *extra-industry* ties provide power, allowing a firm to diversify its ties across different industries and therefore avoid the control by few others who control critical resource exchanges (Pfeffer and Salancik, 1978:131). Similarly, diversifying ties offers the possibility to broker contacts in different industries that would probably otherwise be disconnected. Therefore a firm that spans contacts across industries is less likely to be dependent on each of these contacts, but rather other firms are dependent on the firm itself (Kotter, 1979).

The advantages provided by *extra-industry* ties are not without costs. In fact this type of ties involves higher risks and coordination costs (Burt, 1992). However, we argue that these two disadvantages are mitigated by the presence of a common investor that helps to reduce transaction and coordination costs through its intermediation (Hsu, 2006).

Symmetrically, the main advantage of *intra-industry* ties is that they offer a cohesive environment with a common ground of behavioural rules (Coleman, 1988) and therefore low risk and coordination costs. Further, *intra-industry* ties provide industry legitimacy, and reduce uncertainty regarding the firm's quality. However, VCs already play a strong role providing legitimacy (Stuart *et al.* 1999), information about the

quality of the firm (Sapienza *et al.* 1996), and an environment where failure to comply with the network rules is coupled with severe punishment (Burt and Knez, 1995).[3]

In addition, being dependent on one main industry for connections and resources is likely to increase the firm's competition over the resources; in fact competition tends to arise in organizations that are functionally equivalent, in that they are attempting to produce similar products and services for similar markets (Pfeffer and Nowak, 1976).

Therefore, from the previous discussion we hypothesize that starting from the assumption that entrepreneurial ventures should favour non-duplicative connections, *extra-industry* connections will be more beneficial to the firm's success.

H1: *The VC-backed venture's success will be positively (negatively) associated with extra-industry (intra-industry) ties.*

The optimal combination of *intra-* and *extra-industry* ties

Recent work indicates that usually network forms are not inherently at odds, but rather that ties may benefit the firm but under different conditions (Rowley *et al.*, 2000). For instance Baum, *et al.* (2000) show that increasing the number of connections without considering partner's diversity can create inefficient configurations that generate less diverse information and capabilities at greater costs than a smaller, non duplicative set. Accordingly, various scholars (e.g. Burt, 2000; Provan *et al.*, 2007; Reagans and McEvily, 2003; Reagans and Zuckerman, 2001; Soda *et al.*, 2004; Tiwana, 2008) demonstrate that an optimal network may be the one that combines different elements such as cohesion and structural holes or strong and weak ties.

[3] As concluded by Gargiulo and Benassi (2000) one would expect that actors would favor the safety provided by a dense network in situations where the risk of opportunism and the cost of malfeasance is high and a network rich in structural holes (e.g. extra-industry ties) in situation where trust is not an issue.

We argue that the effect of *intra-industry* ties is positively moderated by the presence of *extra-industry* ties and vice versa. Stam and Elfring (2008) argue that *extra-industry* ties broaden the knowledge base of a highly central firm and increase its capacity to appreciate, recombine, and apply the knowledge that is accessible through its *intra-industry* ties (Cohen and Levinthal, 1990). Put simply, ventures with high *intra-industry* centrality and extensive *extra-industry* ties occupy a unique brokering position that enhance their capability to recognize information asymmetries in the market and connect seemingly unrelated facts into novel combinations (Burt, 2000; Hargadon, 2002). Exposure to new ideas and resources via *extra-industry* ties may outweigh any conformist pressures coming from *intra-industry* ties (Perry-Smith and Shalley, 2003). In addition, being directly tied to other fields makes highly central firms less dependent on industry peers for access to new knowledge and resources (Pfeffer and Salancik, 1978). These ventures are able to verify and triangulate information received from competitors and VCs with information received through bridging ties, thereby enhancing their access to high-quality information that facilitates the pursuit of innovative, high-risk - high-reward opportunities (Stam and Elfring, 2008) that are necessary to achieve an outstanding success. Hence, we argue that a firm has to carefully balance its portfolio of ties in order to combine *intra-* and *extra-industry* ties.

H2a: *Intra- and extra-industry ties complement each other in enhancing the firm's success.*

H2b: *There is an optimal network portfolio composed of a set of intra- and extra-industry ties which leads to the firm's success.*

METHODS

Research setting

The empirical context of this study is the UK venture capital industry during the period 1995-2011. The VC industry is an interesting context because it involves the financing of new or radically changing firms which are different in many important ways to mature, established companies quoted on the stock markets (Wright and Robbie, 1998). VCs usually operate in private finance markets that are often characterized by a low liquidity and information frictions (Bengtsson and Hand, 2011). In this context, networks prove to be useful in reducing information asymmetries, enhancing performance through access to crucial resources and conferring legitimacy. Although networks may play important roles in overcoming such knowledge and legitimacy challenges, most research has looked at established industries (Aldrich and Fiol, 1994; Geletkanycz and Hambrick, 1997). The UK market has been chosen because, although it is the biggest in Europe (EVCA, 2010) and the third most attractive worldwide for this type of investments (IESE, 2010), it has received considerably lower attention than the US market (with research by Abell and Nisar (2007), Chiplin *et al.* (1997), Filatotchev, Wright and Arbeck (2006), Manigart and Wright (forthcoming) being notable exceptions).

Research design and data collection

We collected data from multiple sources to establish the validity of our measures. First, we conducted a qualitative study using field interviews with portfolio firms and venture capitalists (VCs), archival data and a literature review to explore

possible impact of portfolio companies on each other.[4] Based on theoretical and qualitative evidence, we argue that there are strong links between VC portfolio companies. Companies with a common VC investor may exchange experiences and knowledge, rely on the economies of scale in dealings with suppliers and have cross company directorships which may impact their operations. The importance of this type of networks is highlighted by entrepreneurs and investors such as InvestorLab, Kleiner Perkins Caufield and Byers, Rocket Internet, Intel Capital, First Round as well as by scholars (e.g. Hsu, 2006; Lindsey, 2008; Stuart et al., 1999).

We started with interviewing 3 VC backed entrepreneurs and 3 VCs and we gathered secondary data using VC websites among other secondary sources.[5] Online resources taken from VC websites (e.g. iGlobe, First Round Capital, Intel Capital, Rocket Internet, Kleiner Perkins Caufield and Byers-KPCB) illustrate the existence and importance of portfolio company ties. For instance, KPCB, one of the leading US VCs, emphasizes on its website[6]: "Entrepreneurs gain access to our matched portfolio of companies and associations with global business leaders. These relationships are the foundation for strategic alliances, partnership opportunities and the sharing of insights to help build new ventures faster, broader and with less risk". Further, our interviewees

[4] This approach has been proven to be fruitful in the network literature by other scholars such as Gulati (1995), Powell *et al.* (2005), Soda *et al.* (2004), Stam and Elfrig (2008) and Uzzi (1996). For example Gulati (1995) uses interviews in 8 firms to confirm the relevance of his research and Uzzi (1996) refines his framework based on interviews and fieldwork.

[5] Although our main quantitative analyses and data collection is UK based, we conducted interviews also with non-UK based VCs and entrepreneurs and extensively reviewed online resources worldwide. We believe that this procedure does not confound our findings as the western VC standards are common throughout the different markets.

[6] http://www.kpcb.com/contactUs/ , quote retrieved on 28th of July 2011.

explained that two practices are common in the industry in order to foster networking among portfolio companies: CEO/CFO mailing lists and CEO summits.

In addition, various scholars have demonstrated that common third parties (e.g. common VC investor) serve as an incentive to display cooperative image (Burt and Knez, 1995; Gargiulo and Benassi, 2000; Gulati, 1995; Hsu, 2006; Lindsey, 2008; Stuart *et al.*, 1999 Uzzi, 1997).

Further, Powell *et al.* (1996) and Barringer and Harrison (2002) suggest that collaborations in high-tech industries typically reflect more than just a formal contractual exchange and are often stipulated with social contracts rather than legal agreements. Therefore, based on theoretical and practical evidence, we posit that VCs can create an environment where collaborations between their portfolio companies can blossom, but these collaborations are often informal and not legally binding.

Once we established the existence of these links among portfolio companies we gathered VC investment data through the Thomson One Banker database. The database contains the same information as Venture Expert which has been extensively used in the VC literature (Chaline *et al.*, 2012; Gompers, 1995; Hochberg *et al.*, 2007; Lerner, 1994). We included UK based venture companies that received the first VC investment between 1995 and 2008 with records of investments up to the end of 2011. Following the approach used by Hochberg *et al.* (2007), we did not include companies that received their first investment after the 2008 to allow ventures sufficient time to successfully exploit their potential, or eventually fail. On the other hand, the analysis starts in 1995 because prior to this year the Venture One database does not provide a comprehensive coverage of the UK market.

In line with Manigart and Wright (forthcoming), we focused our attention on "young growth oriented venture capital backed companies" that therefore received investment from seed to later stage, therefore excluding buyouts, real estate investments and generally private equity deals. For additional refinement, borrowing from Zahra (1996), we defined new ventures as firms that have been in existence for eight years or less at the time of investment. We also did not consider companies that received investments exclusively from "undisclosed investors" or "individual investors" because this does not allow us to locate the venture within a VC network. The final dataset contains 1264 VC-backed companies, 5344 VC deals made by 733 VC firms. After additional data collection and manipulation, we created a panel of precise network measures for each venture in each year.

Network construction

The database has been initially rearranged to create a matrix of 1264 companies per 733 VCs per 17 years, totalling 15.7 million data points. Venture Expert divides the portfolio companies according to their status: previously or currently VC backed. For previously VC backed companies we hand collected a date and type of exit through multiple database sources such as Zephyr, SDC Platinum, MergerMarket and Venture One. However, when the venture was listed as "Currently VC backed" and there was no evidence of exit or bankruptcy from other databases, we assumed that the VC is still a shareholder in the company. Finally, if the company's exit was coded as "went public", "acquisition", "merger" and at the same time it was not VC backed, an exit date has

been calculated in relation to the stage of the company following Gorman and Sahlman (1989)[7].

Subsequently, in line with our field research and our theoretical underpinnings, we redesigned the network as portfolio-company to portfolio-company matrix. This generated a matrix with 1264 companies and 17 years totalling around 27 million data points. Connecting portfolio companies with each other through a common link with a VC is similar to the network validated by Venkatraman and Lee (2004) that connected game developers through video-games consoles.

Measures

Performance. As previously mentioned, the company trade-sale or IPO is a strong acknowledgment by the market about the company value. Hence, in line with the VC literature our dependent variable of success is represented by a VC exit (e.g. Hochberg *et al.*, 2007). This performance measure is considered to be the most appropriate because, due to the high levels of technological and R&D intensity of the firms in our sample, accounting performance measures may be misleading, especially during early stages. Therefore, an exit is a clear and objective way to assess the entrepreneurial firm's performance and the success of the venture capital investments (Cumming, 2007). IPOs and acquisitions are widely regarded as the best exit outcomes for both the company and the VC (Abell and Nisar, 2007; Cumming *et al.*, 2006; Cumming and MacIntosh, 2003; Gompers and Lerner, 1999; Manigart and Wright,

[7] We assumed that early stage investors reduce the amount of time devoted to companies in the seed stages after 8 years, in the early stages after 7 years, for companies in the balanced and later stages after 3 years.

forthcoming; Megginson and Weiss, 1991).[8] With regard to acquisitions, it has to be noted that this type of exit is not always financially rewarding but we argue that it is a good proxy for value for both the company and the shareholders. Therefore in order to test our hypotheses we used a dummy that takes the value of 1 if the venture has been acquired, merged or went through an IPO in a given year.[9]

***Intra-* and *extra-industry* ties.** In order to test our hypotheses we developed two measures that represent the amount of ties that each venture has in (a) the industry of operations (*intra-industry ties)* and (b) in external industries (*extra-industry ties)*. The two variables are constructed taking into consideration 6 macro industries identified by the Thomson One database: Computer related Communication and Media, Non-High Technology, Biotechnology, Seminconductors/Other Electrical and electronics, Medical/Health/Life Sciences. The choice of the above classification comes from two main reasons: (a) there is a generally even distribution of companies among the six categories compared to more fine-grained segments; and (b) using more precise industry measures reduces the likelihood of a firm to have a connection with a company in the same industry; in fact, even using only 6 industries a single company on average has less than 1 connection in the same industry and 2.5 connections in unrelated industries each year. Based on this industry classification, we developed two distinct matrices for

[8] An IPO is not strictly an exit at the time of the public offering since some of the VCs' equity may be held after an IPO within a lock-up period. However, an IPO still allows VCs to cash in a significant portion of their pre-IPO equity and get their portfolio firm recognized by public market investors as a successful venture.

[9] For example if the firm is in the network from 2000 but went through an IPO in 2003, our performance variable will have 0s from 2000 to 2002, and a 1 in 2003. Within our dataset, 30% of the companies have been acquired, merged or went through an IPO while 7.5% failed. The ratio between write offs and successful exits is in line with the one identified by the British Venture Capital Association for the last available years at the time of this paper (4 years).

each year for each venture representing the ties among the various portfolio companies with a common investor. Therefore, if two companies share the same investor in a given year, they belong to the same network. In addition, the ties have been divided in *intra-* and *extra-industry* based on whether the connections are in the same or in different industries with regard to the focal company. Hence, each venture in any given year of its life has two set of connections: *intra-* and *extra-industry* connections. We then created an interaction effect by multiplying the *intra-* and *extra-industry* network variables in order to test our hypothesis 2a.

In addition, to test hypothesis 2b we include two different but related measures:

Concentration of ties. We include a concentration index that helps us to better understand the best combination of ties. We create an index based on the following Herfindahl formula, where *S* represents the proportion of ties in each network, we created yearly concentration measures of ties. Therefore if a firm in a given year has only *intra-* or *extra-industry* ties, rather than a combination of the two, will have a concentration measure of 1. Similarly, if it has 50% ties in each of the networks, this index will have a value of 0.5.

$$H = \sum_{i=1}^{N} S_i^2$$

Proportion of ties. Finally, in order to shed additional light on the optimal concentration of ties as suggested in hypothesis 2b, we calculated the proportion of *intra-* and *extra-industry ties* based on the following equation where C is the concentration of ties both for I (*intra-industry ties*) and E (*extra-industry ties*)

$$C_I = \frac{I}{I+E} \text{ and } C_E = \frac{E}{I+E}$$

Further, we tested the robustness of our findings with alternative measures of networks such as *betweenness*, *Bonacich power* and *eigenvector* generated for both types of networks (for a detailed discussion of these measures see Bonacich, 1987; Borgatti *et al.*, 2002; Freeman, 1977; Hochberg *et al.*, 2007).

Control variables. To ensure the robustness of our findings and to rule out alternative explanations we include a number of controls. Brander *et al.* (2002) find that syndication is associated with higher returns. Therefore, we include the *Number of co-investors* in each venture over its life.[10] Kaplan and Schoar (2005) show that returns are persistent across a sequence of funds managed by the same VC firm. Hence it can happen that older VC are more reputable and therefore invest in more successful ventures within their portfolio and this could create a similar bias to the one previously mentioned (Podolny, 2001). Therefore, we include the *VC Experience* which is represented by the logarithm of the total number of companies invested in to date by the lead investor[11]. In addition we also include dummies that classify the *Stage of the VC* fund investing in the company (i.e. Early stage, Balanced Stage, Later Stage, Other). Further, we check whether the lead VC fund is *UK based* (dummy with value 1 if UK based) and whether the fund and the portfolio company have their headquarters in the

[10] To control for the effect of syndication we follow the definition of Lockett *et al.* (2006) that defined an equity syndicate as two or more venture capital firms taking an equity stake in an investment for a joint payoff, either in the same investment round or at different points in time (Brander *et al.*, 2002).

[11] This measure is calculated for each venture from the inception of the lead VC to the time of the first investment in the portfolio company. An option to include VC measures considering the lead investor only is suggested by Gorman and Sahlman (1989). They theorise that when VCs play a lead investor role, they devote much more time than non-lead or late-stage investors, and they invest in every round with a bigger amount of capital overall. Hence, we identified a lead investor as the first VC to invest in the company. We do not have data about the investment for a reasonable number of companies to check the effective size of the investment. In unreported tests we also controlled for VC age and results are consistent. However, due to collinearity issues, we could not include both measures simultaneously.

Same city (dummy with value 1 if in the same city). These measures are likely to account for the potential networking spillovers generated by the VC proximity that it is known to be relevant in the VC investments (Cumming and Dai, 2010; Sorenson and Stuart, 2001). Further, to control for market conditions we gathered from the World Federation of Exchanges the yearly net amount of listed companies on the London Stock Exchange (*LSE*)[12]. Control measures related to the ventures include dummies for the *Industry* of operations, the *Age at financing* and the dynamic *Age*. For example if a venture is 12 months old at the time of the VC investment in 2005, the *Age at financing* measure will be 12 all over the company's life. Differently, the dynamic *Age* will be 12 in 2005, 24 in 2006, 36 in 2007 and so forth.

Analytical methods

In order to test our hypotheses we run a longitudinal logistic regression with random effects that tests the impact of our predictors on the likelihood of a venture to have a successful exit. The fixed effect model using dummy variables to control for firm or time differences is not appropriate since some explanatory variables are time-invariant (Gulati, 1995: 652; Hausman and Taylor, 1981).[13] Further, as reported by Lincoln *et al.* (1996) OLS gives inefficient estimates of slopes and (negatively) biased estimates of standard errors with pooled cross-section/time series data because it fails to take into account the error components common to the same firms in different periods and different firms in the same periods. Therefore, the random effects model applied to a logistic regression is the most appropriate estimation technique. Further, we

[12] This measure represents the new listings minus the de-listings.

[13] As a robustness test we run a model with fixed effects including only time varying measures. The results of this test are explained in the next sections.

standardized our network measures of around the Z-score to avoid high inter-item correlations among the interaction terms (Gao, Gopal, & Agarwal, 2010). Therefore the variables *Intra-* and *Extra-industry* ties have been standardized and after this procedure we interacted the variables following Friedrich (1982).

Results

Table 1 and 2 report the descriptive statistics and correlations. Within our sample more than 74% of the firms had the lead investor based in UK and 20% of the companies were located in the same city of their investor. With regard to the fund stage, the sample is approximately evenly spread within the 3 stages: early (42%), balanced (28%) and later (21%), with just a few companies in "other" stage (7%)[14]. The most represented industry sectors are "Computer Software and Services" and "Internet Specific" which represent almost half of the firms. Further, the average firm received the first VC investment 31 months after the inception from 3 VCs co-investing together, with a maximum of 22 firms co-investing in Oxagen Ltd. The average age of the company in our panel is 5.7 years. With regard to the networks' size we can see that the results are highly skewed. In fact, even though the average is 1 and 2.4 for *intra-* and *extra-industry* connections respectively, the maximum amount of connections is 39 and 83. Finally, on average 56 new companies have been listed on the London Stock Exchange every year.

----------Table 1 and 2 about here----------

[14] This measure is related to the stage of the VC fund, but it can be considered a proxy for the stage of the company as well. This measure is conceptually different from the *Age* since not all companies need the same time to reach the same stage of development.

Table 3 reports results of the logistic regression. At the first step we entered the control variables. Not surprisingly, in hot market conditions (*LSE*) ventures have higher probabilities to reach a successful exit. Further, in line with the literature, although not significant in this model, *VC experience* positively impacts the success of the firm. Moreover, even though older ventures have higher probability of exiting successfully, the earlier the firm receives its VC investment, the higher its likelihood of success. Finally, geographical proximity with the investor, in terms of city but not country, has a strong impact on the successful exit of the venture.

----------Table 3 about here----------

In the second step we entered our main independent variables to test our hypotheses. H1 suggests that the venture's success will be positively (negatively) associated with *extra-industry* (*intra-industry*) ties. In model 2 we find support for this hypothesis since the *extra-industry* ties' coefficient is positive and highly significant ($p < 0.001$) and *intra-industry ties'* coefficient is negative and significant ($p < 0.05$).

In the third step we test our H2a that posits that there is a positive interaction effect between ties. Put simply, the higher the amount of one type of tie, the higher the benefits received from the other ties, and vice versa. In model 3 we include the interaction effect between the two types of networks and we find that is positive and highly significant ($p < 0.001$). Therefore we demonstrate that the two types of networks complement each other as hypothesized in H2a.

In the last steps (models 4 to 5) we test H2b that predicts that the optimal portfolio of ties is composed by both types of ties. In model 4 we insert the measure that represents the concentration of ties. If our hypothesis is supported this variable has to be negative, showing that the higher the concentration of ties, the lower is the firm's likelihood of success. Hence, since the coefficient is negative and highly significant ($p < 0.001$) we find support for H2b. Further, in order to shed additional light on the optimal portfolio composition, in model 5 we introduce the proportion of *intra-industry* ties and its squared measures. In unreported analyses we tested the impact of the proportion of *extra-industry* ties. Since both squared measures are negative, we conclude that a diversified set of ties is preferable, and the optimum combination is centred around *extra-industries* connections.[15]

Looking at the overall fit of each of the models indicated by their log likelihoods and associated Wald chi-squares, it can be noted that the introduction of the amounts of ties in model 2 significantly improves the fit of the base model. Another significant improvement occurred in models 3 with the introduction of the interaction effect. Finally, there is a notable improvement in model 4 and 5 compared to model 2, with the introduction of the variables for concentration of ties, and the proportion of each type of ties. Fig. 1 summarizes these main effects showing the impact of our independent variables, the combination of the two and their proportion on the likelihood of success. In all the graphs, the y-axis represents the likelihood of having a successful exit.

----------Figure 1 about here----------

[15] Note that we cannot include in the same model both proportion of ties as they are symmetric.

The top graph in Figure 1 shows the impact of *intra-* and *extra-industry ties* on companies' performance. Clearly, the higher the amount of connections outside of the focal firm's industry, the better the performance. On the other hand, connections in the same industry hinder firm's performances. The graph in the left corner of Figure 1 illustrates that once a firm moves away from a balanced set of connections its performance will be affected. Similarly, as previously discussed (right corner graph), a balanced combination of ties is preferable over a concentrated distribution. It can be noted that once a firm has a portfolio with more than 40% of *intra-industry* ties, it will have lower chances of success. On the other hand, a firm that goes over a proportion of *extra-industry* ties of about 60% will reduce its likelihood of success. Hence, the best combination of *intra-* and *extra-industry* ties seems to be approximately 40/60% respectively.

Robustness tests

We conducted several robustness tests. First, we run different specifications of the model using panel regression (*xtreg*) and we obtained similar results with the directions and significances of the main effects remaining constant. In addition, we run a fixed-effect model without the time invariant measures, and the direction of the coefficients is consistent but the significance is lower. Further, we re-run the same type of regression but instead of using a raw amount of ties we included more elaborate measures such as *betweenness, eigenvector* and *Bonacich power* created from *intra-* and *extra-industry* matrices. In addition, we also "weighted" the connections between firms by the geographical distance between the two ventures; in all these tests we had the same direction of the coefficients although we found lower statistical significance for

our measures. Finally, in order to rule out the possibility that more successful firms become more connected (a reverse causality argument), we lagged our network measures by 2 years, and the results remain unchanged and statistically significant.

Discussion and conclusions

This study reveals that the configuration of *intra-* and *extra-industry* networks can explain both positive and negative performance of a firm. We provide empirical support to arguments by Podolny and Baron (1997) and Peng and Luo (2000) and demonstrate that not all ties and networks have the same impact on performance. Although the total amount of ties has a positive effect on performance, we demonstrate that different ties have different impacts. First, *extra-industry ties* give access to new information and knowledge (Christensen and Raynor, 2003; Duysters, 1996) and, in turn, increase company performance. This finding shows that in innovative and dynamic contexts firms gain more benefits from accessing novel knowledge which is likely to be found outside the industry of operations rather than from simply increasing the number of ties.

Second, young firms backed by VCs do not benefit directly from *intra-industry* ties. We argue that, in this context, the VC is a strong mediator of the resources that a venture gains in its industry, therefore mitigating the network benefits. However, as highlighted by Gargiulo and Benassi (2000) and Baden-Fuller *et al.* (2011), networks are costly to maintain and in our case it appears that these costs are not offset by the *intra-industry* network advantages. However, we also find that, once a venture manages to connect with an extensive amount of firms outside its industry, it is able to profit from the connections in its industry of operation as well. Put differently, although the

intra-industry network taken independently has a negative impact, once a venture establishes a critical mass of *extra-industry* ties, it is able to benefit from its *intra-industry* ties. Figure 1 illustrates that the processes behind the impact of ties on shaping company performance are not straightforward, and there is an optimal combination of ties that involves both types of connections. We posit that, in order to thrive, a new firm needs to have a richer set of ties which provides access to different types of resources and opportunities.

Contributions

Research has only started to recognize and systematize the value of knowledge, technologies, and partners located in different industries (Enkel and Gassmann, 2010). Within this field of research, this paper provides several contributions. First, we show empirically that the effects of *intra-* and *extra-industry* ties on firm performance are different but inextricably linked. Taken in isolation, *intra-industry* ties do not seem to offset the cost of managing them. However, once they are coupled with *extra-industry* ties, it looks like a firm manages to profit from both types of ties. Hence, we show that different ties mutually shape their contribution to firm performance. The fact that *intra-industry* centrality and *extra-industry* bridging ties have complementary effects on ventures' success provides initial empirical support for recent research arguing that internal and external social capital may have interactive effects (Mehra *et al.*, 2006; Oh *et al.*, 2004; Stam and Elfring, 2008). Supporting the notion that social capital has contingent value (Ahuja, 2000), in particular in relation to the nature and content of the ties, this study shows that different network configurations shape the effect of networks and that different types of networks affect each others' value. The results highlight the

need to examine not only the interactions among different forms of social capital, but also the contingencies that determine the optimal balance of ties.

Second, this paper also advances literature pointing to the "dark side" of social capital (Baden-Fuller *et al.,* 2011; Gargiulo and Benassi, 2000). The results emphasize that by simultaneously examining different types of networks, we offer a better understanding of the conditions under which network centrality is detrimental to performance. Previous research has shown that firms can become over embedded in cohesive networks of strong ties (Uzzi, 1997). Accordingly, as suggested by Stam and Elfring (2008), over-embeddedness can also be viewed as an imbalance between internal and external social capital. This idea suggests that considering a firm's embeddedness only in one network may generate misleading results due to overlooking other types of networks. Borrowing from Stam and Elfring (2008) we examined the optimal configuration of a firm's ties across multiple networks and showed that a balanced set of ties, with a stronger presence of *extra-industry* ties, is needed to succeed in an entrepreneurial setting.

Third, we contribute to the long standing debate between closure (Coleman, 1988) and structural holes (Burt, 2001). In line with Burt's argument we show that a firm that has access to different industry segments gains new knowledge, and with this background can profit from its *intra-industry* network centrality. However, we show that structural holes are important not only because they connect unconnected firms, but also because they connect unconnected industry segments. Future research may look at the differences between structural holes that connect companies in the same or unrelated industries.

Lastly, although the importance of networks in the VC world has been demonstrated, we believe that this is the first attempt to assess the value of the connections that a firm have access to through a portfolio of VC-backed companies. Consistent with the view that VCs provide more than capital, we find that investors add value to their investee companies, providing a fruitful environment for collaboration among their companies. This finding is supported by both archival data and by interviews with VC managers. In practice, venture capitalists promote a vibrant environment organizing recurring summits where all the portfolio companies are invited, by linking these companies directly, and by creating databases that connect the CEOs and CTOs of their companies for a joint problem solving. We extend the VC literature that advocates the value adding activities provided by the VCs (for an extensive review see Manigart and Wright, forthcoming). Contributing to this research we show that VCs provide access to a potentially valuable network composed by their portfolio companies. However, not all companies benefit from all the connections but rather it is important to establish the right links within this network.

Limitations and directions for future research

Our results have several implications for the current debate on the relationship between networks and success. However, we would like to acknowledge some limitations and recommend caution when extracting conclusions, and suggest the importance of future research on the topic. The main limitation of this research is that it cannot demonstrate whether an alliance has been really established or that a VC effectively initiated a collaboration between portfolio companies. However, according to Powell *et al.* (1996) exploratory study, the official partnerships are just a small

portion of the entirety. Similarly, Hite (2005) argues that embedded ties are generally governed through informal mechanisms of relational governance such as trust and relational contracting rather than through more formal mechanisms of market governance such as contracts (Granovetter, 1985; Uzzi, 1996, 1997; Williamson, 1979; Zaheer and Venkataraman, 1995). Further, as it has been mentioned by VCs and entrepreneurs that we have interviewed, only a small portion of these collaborations is contractualized and that the VC is "a small world governed by trust". Therefore, if we would consider only the joint ventures publicly communicated, we would lose all the other indirect information and resource exchanges that are fundamental to the success of the new firms. However, further research could include more fine grained networks' measures, for instance combining official alliances with measure of informal collaborations. In addition considering the highly significant personal networks of VCs and entrepreneurs, both formal and informal, would offer interesting insights.

Further, our network measure is based on horizontal firm differentiation (e.g. different industries); hence we do not control for ties spanning across vertical sectors. For example, would the *intra-industry* ties effect be the same if the two companies operate in different points of the value chain? Or maybe this type of ties provide the same, if not higher, benefits than *extra-industry* ties? A useful extension of this research would examine both *intra-* and *extra-industry* ties, as well as vertical versus horizontal ties.

Furthermore, a very interesting avenue for future research is represented by the different degree of network effectiveness contingent on the life cycle of the firm. In their conceptual paper, Hite and Hesterly (2001) postulate that the networks of emerging firms evolve in response to the changing resource's needs and acquisition

challenges of the firm as it moves through the life cycle stages of emergence and early growth. This dynamic network evolution is the process by which firms strategically adapt and align their networks to gain the resources they need to ensure successful emergence and early growth (e.g. Golden and Dollinger, 1993; Ostgaard and Birley, 1994). Therefore, testing the contingent effect of resource availability accessible through *intra-* and *extra-industry* networks and life cycle of the firm is a promising extension of this study. In fact, it can be hypothesized, borrowing from the resource-based notion, that firms cooperate in order to gain access to critical resources and considering that older firms *pari passu* have higher resources, they will gain less benefit from wider networks.

Moreover, we looked at the success of the venture in reaching a positive exit. It would be interesting to see what is the impact of different types of ties on innovation, and as well how innovation shapes the network configuration of a firm. For example, are new ventures more inclined to partner with an innovative firm in their industry rather than with an outsider?

Finally, we considered only one market, the United Kingdom, in one particular context, the VC industry. This leads us to concerns about generalizability of our findings. It would be interesting to understand the impact of different networks of portfolio companies in other markets, potentially taking into consideration institutional factors. This network can be centred in other countries or take into account cross-country relationships. Therefore testing whether institutional factors such as IP protection or cultural factors have an impact on this knowledge sharing is an interesting question that we leave unanswered.

Practical implications

Possible limitations notwithstanding, the present research offers several practical implications. The findings reveal that entrepreneurs can enhance the performance of their ventures by simultaneously increasing the amount of *extra-industry* ties and at the same time connecting with ventures in their industry. Yet, entrepreneurs should be aware that a strong balance in favour of *intra-industry* ties may constrain performances when an *intra-industry* centrality is not accommodated by sufficient *extra-industry* bridging ties. Considering this potential trade-off between building different social capital conduits, an important challenge for entrepreneurs concerns balancing their efforts at strengthening their *intra-* and *extra-industry* networks simultaneously and strategically. Entrepreneurs are encouraged to support initiatives that may foster the development of *intra-industry* ties, but at the same time, the findings suggest that such networking activities may be costly to manage and do not provide the expected benefits if are not complemented by initiatives that support the creation of *extra-industry* ties. Further, in addition to considering the different value adding activities and resources offered by a VC, when approaching investors the entrepreneurs should look at what companies they can gain access to through their investors to be; companies may be better off by selecting VCs that focus on diverse industries so that they obtain financing from highly specialized VCs but at the same time accessing opportunities with portfolio companies in different industries. Symmetrically, VCs should invest in new ventures not only for their potential, but also for their network that may in turn benefit their portfolio companies.

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Table 1. Descriptive Statistics

Variable	Mean	SD	Min	Max
Successful exit	0.0511	0.220	0	1
Intra-Industry ties	0.9320	3.052	0	39
Extra-Industry ties	2.4371	7.315	0	83
Co-investors	3.0694	2.782	1	22
Age at Financing	31.2573	23.521	0	84
VC/Venture=City	0.1957	0.397	0	1
UK Fund	0.7466	0.435	0	1
Early Stage	0.4216	0.494	0	1
Balanced Stage	0.2871	0.452	0	1
Later Stage	0.2179	0.413	0	1
Other Stage	0.0734	0.261	0	1
Computer SW	0.2046	0.403	0	1
Internet	0.2082	0.406	0	1
Communication	0.0903	0.287	0	1
Consumer	0.0628	0.243	0	1
Other Products	0.0994	0.299	0	1
Industrial	0.0507	0.219	0	1
Biotechnology	0.0906	0.287	0	1
Computer HW	0.0270	0.162	0	1
Semiconductors	0.0663	0.249	0	1
Medical/Health	0.1000	0.300	0	1
VC experience	1.8359	0.781	0	3.87
LSE	56.8070	193.624	-211	492
Venture’s Age	5.7053	3.196	0	19.25

Table 2. Correlation among the main variables

		1	2	3	4	5	6	7	8	9	10	11	12
1	Successful exit												
2	Extra-industry	0.01											
3	Intra-industry	0.00	0.68										
4	Interaction	0.01	0.70	0.81									
5	Concentration	-0.03	0.20	0.06	-0.02								
6	Proportion of ties	0.00	0.34	-0.02	0.08	0.42							
7	Co-investors	0.02	0.01	0.01	0.01	0.03	0.03						
8	Age at Financing	-0.01	0.01	0.00	0.00	0.05	0.04	0.00					
9	VC/Venture=city	0.01	0.01	0.04	0.02	0.00	-0.03	-0.04	-0.08				
10	UK Fund	-0.01	0.02	0.01	0.01	0.06	0.05	-0.11	0.04	0.25			
11	VC Experience	0.05	0.00	-0.01	-0.01	0.07	0.02	0.11	0.07	-0.16	-0.12		
12	LSE	0.00	-0.05	0.03	-0.02	0.08	-0.20	-0.03	-0.03	0.02	-0.01	0.00	
13	Venture's Age	0.09	0.00	-0.01	-0.03	0.03	0.07	0.10	0.58	-0.06	0.03	0.00	-0.15

Table 3. Random Effects Panel Logistic regression. Dependent variable: Successful exit

	Model 1	Model 2	Model 3	Model 4	Model 5
Control Variables					
Co-investors	-0.03* (0.02)	-0.03* (0.02)	-0.03* (0.02)	-0.03 (0.02)	-0.03 (0.02)
Age at Financing	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)	-0.02*** (0.00)
VC/Venture=City	0.27* (0.14)	0.29** (0.14)	0.30** (0.15)	0.29* (0.15)	0.29** (0.15)
UK Fund	-0.24* (0.13)	-0.25* (0.13)	-0.24* (0.13)	-0.21 (0.13)	-0.21 (0.13)
VC Experience	0.11 (0.07)	0.11 (0.07)	0.12 (0.07)	0.14* (0.07)	0.14* (0.07)
LSE	0.00** (0.00)	0.00** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Venture's Age	0.25*** (0.03)	0.25*** (0.03)	0.26*** 0.03)	0.26*** 0.03)	0.26*** 0.03)
Network measures					
Intra-Industry†		-0.17** (0.08)	-0.40*** (0.12)	-0.39*** (0.12)	-0.37*** (0.12)
Extra-Industry†		0.19*** (0.06)	0.12* (0.06)	0.22*** (0.07)	0.19** (0.08)
Interaction Intra*Extra†			0.07*** (0.02)	0.05* (0.02)	0.05** (0.02)
Concentration of ties†				-0.25*** (0.07)	
Proportion of Intra-industry ties‡					2.80*** (0.77)
Proportion of Intra-industry ties^2					-3.28*** (0.96)
Constant	-3.803*** (0.58)	-3.752*** (0.58)	-3.163*** (0.40)	-4.01*** (0.41)	-4.44*** (0.49)
Industry dummies	YES	YES	YES	YES	YES
Fund stage dummies	YES	YES	YES	YES	YES
Wald chi-square	95.8***	102.71***	105.43***	105.88***	107.47***
Log likelihood	-1417.2	-1413.3	-1409.1	-1401.6	-1401.0

*** p<0.01, ** p<0.05, * p<0.10. †Measures centralized around the Z-score. In unreported analyses the proportions of *extra-industry* ties has a coefficient of 3.76***(1.3) and its squared measure -3.28***(0.96).

Fig. 1 Main network effects