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Strategic alliances by venture capital backed firms: an empirical examination

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Abstract A growing body of literature examines the formation of strategic alliances as an important value-added role provided by venture capital firms. This paper contributes to this literature by examining two related questions: whether venture capital firms use strategic alliances as a substitute or compliment to capital infusion, and how venture capital firms use alliances to mitigate different types of risk. Results from 2505 venture-backed startups reveal that venture capital firms treat alliance formation as a substitute for capital infusion and that the breadth of the network of syndication partners investing in the startup increases the number of its strategic alliances. We also find intentionality in alliance formation. Specifically, firms operating in industry environments characterized by technical risk are more likely to form alliances with partners capable of mitigating technical risks, and firms operating in environments characterized by market risk are more likely to form alliances with partners capable of mitigating market risk. Our findings lend additional support to the perspective that alliances represent an important mechanism through which venture capital firms add value to their portfolio companies.

Keywords Strategic alliances · Resource-based theory · Venture capital

JEL Classifications D74 · G24 · L26 · Q55

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1 Introduction

Venture capitalists find, fund, and assist high-impact entrepreneurs—individuals whose firms are instruments of Schumpeter's (1939) "creative destruction" and the "creation of new economic spaces" (Acs 2008). In addition to providing the risk capital essential for the development of high-growth entrepreneurial firms, venture capitalists also add value to portfolio companies by helping them recruit key technical and

managerial talent (Gorman and Sahlman 1989; Hellmann and Puri 2002), providing advice and oversight (Bygrave and Timmons 1992; Gompers 1995), facilitating the opening of new markets (Lockett et al. 2008) and shepherding the firm through the initial public offering or trade sale process (Filatotchev et al. 2006).

This study contributes to a small but growing body of literature examining the role of strategic alliances as a mechanism through which venture capitalists add value to their portfolio firms. Lindsey (2008) finds that strategic alliances are more frequent among companies that share a common venture capitalist, suggesting that venture investors use their specialized knowledge to govern the flow of information and identify profitable alliance opportunities. Hsu (2006) demonstrates that venture-backed startups form significantly more strategic alliances than a comparable set of startups that do not have venture backing. While we know that venture capitalists promote inter-firm alliances, within the context of venture capital research the only answer for why this is the case is that venture-backed firms with more alliances are at greater hazard for going public (Ozmel et al. 2007) and tend to have higher valuations at the time of the initial public offering (Chang 2004; Nicholson et al. 2005; Stuart et al. 1999).

Incorporating the theoretically rich and well-developed literature from strategic management allows us to examine alliance formation in venture-backed startups in a new way. Our paper incorporates theoretical insights from the resource-based view (Das and Teng 2000; Eisenhardt and Schoonhoven 1996), the transaction cost view of relational investing (Carroll and Teece 1999), along with empirical work on alliance strategies for small firms (Arino et al. 2008; Gomes-Casseres 1996) to construct a theoretical framework and testable hypotheses that explain the role of alliance formation in startups. Our paper contributes to growing body of work on alliance formation in high-growth new ventures by examining two distinct, but related research questions: whether venture capital firms use strategic alliances as a substitute or compliment to venture capital, and how different types of strategic alliances might be used by venture capitalists to mitigate risk.

Venture capitalists face both *internal risk* and *external risk* when funding entrepreneurs (Kaplan and Stromberg 2003a, 2004). Internal risk arises as a result of information asymmetry and agency problems between the venture capitalist and the entrepreneur. External risk arises from the environment and is normally beyond the control of either party. The mechanisms that venture capitalists use to resolve internal risk have been the subject of significant theoretical and empirical works (Amit et al. 1990; Gompers 1995; Lehmann 2006; Wright et al. 2002b). In contrast, limited attention has been paid to the mechanisms that venture capitalists employ to mitigate external risk. This study examines the formation of strategic alliances as one mechanism by which venture capitalists mitigate external risk for portfolio firms, and thus add value to them.

This study makes three main contributions. First, by providing evidence of how alliances in venture capital-backed firms mitigate external risk, we document the value-added role that venture capitalists provide. A second contribution is in demonstrating that, for venture capital-backed firms, alliances are used as a substitute for capital through their ability to mitigate technical and market risk. Our paper highlights the unique role of venture capitalists in this process: venture capital investors provide their portfolio firms with legitimacy, reduce search costs for resource-starved new ventures, and reduce expropriation concerns through the monitoring and the punishment of non-cooperative behavior.

The following sections of this paper is structured as follows. Section 2 incorporates the respective bodies of literature on venture capital and strategic alliances to construct two sets of hypotheses concerning the formation of strategic alliances in venture-backed firms. First, we examine whether venture capitalists treat alliances as a substitute or compliment to capital infusion; then, we examine the relationship between investment syndication and alliance formation. In Section 3 we detail the data collection procedure and methodology. Section 4 presents our empirical results. Section 5 summarizes our findings, discusses the limitations of this study, and suggests opportunities for future research.

2 Literature review and development of hypotheses

A central concern of venture capital scholarship has been the identification and examination of the appropriate incentives and controls used by investors to

mitigate internal risk arising from asymmetric information between the venture capitalist and entrepreneur. Bounded rationality gives rise to information asymmetry, which provides both the entrepreneur and the venture capitalist with the means to engage in opportunistic behavior (Christensen et al. 2008). Agency theory has emerged as the dominant theoretical perspective from which to view this relationship (Arthurs and Busenitz 2003; Gompers and Lerner 2004).

The consequence of information asymmetry in the entrepreneurial context is the inability to verify the outcomes of the actions of the entrepreneur and, therefore, the inability to write contracts contingent on future states of the world (Kaplan and Stromberg 2003b). Agency costs arise because the goals of investors and entrepreneurs conflict and because investors cannot effectively verify the agents' activities (Eisenhardt 1989; Jensen and Meckling 1976).

Financial economists argue that venture capitalists are specialized financial intermediaries that exist in large part to address these challenges, having evolved a series of organizational and contractual mechanisms to reduce internal risk and increase alignment between the investor and entrepreneur (Gompers and Lerner 2004). These mechanisms include sourcing deals from trusted contacts (Shane and Cable 2002), conducting extensive due diligence (De Clercq et al. 2006), syndicating investment with other partners (Admati and Pfleiderer 1994; Lerner 1994), meting out financing in discrete stages (Gompers 1995), formal and informal monitoring (Lerner 1995; Sahlman 1990), and designing compensation contracts that explicitly tie the fortunes of top managers to the future of the company (Baker and Gompers 2000; Gompers and Lerner 2004; Kaplan and Stromberg 2004).

However, another important challenge in venture investment is external risk. Entrepreneurial companies receive venture financing at extremely early stages of development and often pursue unproven business models, new-to-the-world technologies, or untapped markets. Uncertainty arises with respect to whether a proposed technology will result in a successful product or service offering, as the rapid pace of technological innovation in an industry may make the innovation obsolete before it can be brought to market. The nature of product markets themselves are subject to variation due to shifts in the intensity of competition, uncertainty about the total number of customers in a market, and general economic conditions. Indeed, recent events in the financial markets underscore the fact that the supply of capital from public investors and the price at which that capital is available can vary rather dramatically. While these risks are evident, they are also difficult to manage—for both the venture capitalists and the entrepreneurial firm.

Scholarly research on the mechanisms venture capitalists use to mitigate internal risk is well documented and theoretically evolved. In contrast, relatively little is known about how venture capitalists make strategic choices to mitigate external risk (Kaplan and Stromberg 2004). However, some studies suggest that venture capitalists may actually be *more* concerned with monitoring and mitigating external risk, precisely because well-evolved organizational and contractual mechanisms are in place to mitigate internal risk (Fiet 1994; Gifford 1997; Wright et al. 2002a).

In practice, venture capitalists are very concerned with the highly uncertain environment surrounding the firm and actively attempt to mitigate external risk. For example, Sequoia Capital, a leading Silicon Valley venture capital firm, organized a meeting of CEOs from its portfolio companies to advise them on the implications of the economic downturn and the 2008 credit crisis. In a presentation delivered to portfolio CEOs and subsequently distributed over the Internet, representatives from Sequoia Capital encouraged their portfolio companies to cut costs, preserve cash, and come up with a plan to survive and emerge on the other side of the downturn, which they projected could last years (Eldon 2008).

Early research on venture capital investment documented that venture capital firms emphasize their role as value-added investors, providing more than just "dumb money" to their portfolio firms. In financing environments where "too much money is chasing too few deals", venture capital firms promote themselves as active partners committed to adding value, not disinterested portfolio managers. It is certainly the case that venture capitalists believe they add value, when asked (Pratch 2005), and evidence suggests that for venture capital firms to survive as financial intermediaries, they must provide some value other than capital (de Bettignies and Brander 2007). Venture capital firms contribute managerial expertise and assist in the recruiting of key executive and technical staff, helping the firm "professionalize" (Bygrave and Timmons 1992; Hellmann and Puri 2002; Sapienza et al. 1996). This type of value-

added activity is predicated on the capability of the venture capital firm to tap extensive networks of headhunters, patent lawyers, investment bankers, and advisory services to help the company succeed (Gorman and Sahlman 1989; Hsu 2004; Sahlman 1990).

Extant research also provides descriptive and empirical evidence that venture capital firms facilitate inter-organizational cooperation (Hsu 2006; Lindsey 2008). The formation of strategic alliances may be a way to address the challenges associated with external risk. Organizations form alliances when they are in disadvantaged strategic positions and require additional resources to compete effectively. Small firms are no exception (Garayannis et al. 2000), especially firms "competing in emergent or highly competitive industries or because they are attempting pioneering technical strategies" (Eisenhardt and Schoonhoven 1996).

From this perspective, alliances benefit firms by providing access to complimentary assets, allowing them to conserve resources and obtain new competencies (Gulati 1998; Mowery et al. 1996; Prashant and Harbir 2007). For high-growth entrepreneurial firms in particular—the ones most likely to seek venture capital—alliances are of particular importance, as these firms typically lack the complete set of firm-specific assets and resources required to develop and scale a business concept. As a result, a growing body of literature has examined the alliance behavior of small firms, arguing that the alliance process is an important mechanism through which these firms gain access to the resources crucial to their success (Arino et al. 2008; Das and Teng 2000; Eisenhardt and Schoonhoven 1996; Garayannis et al. 2000; Gomes-Casseres 1996). Entrepreneurs certainly seem to think that this is the case, since they are willing to pay more in order to affiliate with venture capital firms with a high reputation in order to gain access to these valuable resources (Hsu 2004).

Alliances confer other potential benefits to high-growth entrepreneurial firms beyond overcoming resource constraints. They can also provide endorsement and legitimacy to firms with a limited track record (Stuart et al. 1999). Investors and customers facing uncertainty about the quality of a firm may use the relative prominence of affiliates and partners of the new venture to make assessments of its quality. Studies have shown that both the count and the prominence of alliance partners are positively related to the stock market valuation of start-up firms (Nicholson et al. 2005; Stuart et al. 1999).

Alliance opportunities also come with significant potential risks (Koza and Lewin 1998; Singh and Mitchell 1996). Many of these risks are exacerbated in young, less-established firms. Searching for potential exchange partners can be costly (Arrow 1974) given the various expenses occurred when conducting research, due diligence, and contracting (Wernerfelt 2004). The relative importance of the alliance has been shown to influence the depth of the search and due diligence process (Harbison and Pekar 1998), the extent of contact negotiations (Ring and Van de Ven 1992), and the complexity of the final contract (Reuer et al. 2006). Entrepreneurial firms are likely to experience higher search costs given their resource constraints, the relative importance of the partnership to the firm, and the risk associated with its failure.

While the cost and importance of the alliance augments the overall cost of contracting (Williamson 1985), an uncertain external environment also influences contracting, leading to incomplete and less complex contracts (Crocker and Reynolds 1993). Contracts are usually incomplete because the parties can neither anticipate nor reliably observe possible outcomes. Innovative, high technology startups—the type of firm most likely to attract venture backing—operate in conditions of extremely high technical and market uncertainty (Gompers et al. 2008; Gompers and Lerner 2004), which increase the opportunity for expropriation (Oxley 1997) or information spillovers. Leaking information to potential competitors can reduce the rents generated by the entrepreneurial opportunity, and this threat can impede the formation of strategic alliances (Branstetter and Sakakibara 2002; Khanna et al. 1998).

As a result of these challenges, an important consideration for small, innovative firms is mitigating the potential risk of expropriation given the impact of uncertainty on partnership agreement, completeness, and complexity (Arino et al. 2008; Deeds and Hill 1998; Gomes-Casseres 1996).

Experienced entrepreneurs, such as Marc Andreessen (founder of Netscape Communications Corporation, Opsware, and Ning), are keenly aware of the risks that partnerships with established firms pose to young high-technology firms:

> "A big company might study you for 3 months, then approach you and tell you they want to invest in you or partner with you or buy you, and then vanish for 6 months, then come out with a directly competitive product that kills you…or just make you waste a huge amount of time in meetings and get distracted from your core mission." (Andreessen 2007).

Venture capital firms have both the motivation and the capability to help their portfolio firms forge strategic alliances. Alliances enable the new venture to avoid the cost of internalizing transactions, an area of particular concern for resource-constrained new ventures. In addition to conferring legitimacy, venture capitalists are likely to reduce transacting problems, as contractual arrangements in this uncertain context are often less detailed, more open-ended arrangements (Arino et al. 2008; Deeds and Hill 1998; Gomes-Casseres 1996; Gulati 2007; Singh and Mitchell 1996). Venture-backed firms, therefore, are likely to enjoy lower transaction costs overall, increasing the likelihood of its survival and growth.

Specifically, the expertise and social network of a venture capitalist may help to mitigate many of the obstacles that entrepreneurial firms face when establishing strategic alliances. Through their role as monitors, venture capitalists have access to timely, detailed information about the level of development of the firm's core technology and its market strategy. They can use this knowledge to reduce partner search costs by applying their general business knowledge to identify areas of the business where alliance partnerships would be most fruitful—and then tap their network to broker these collaborative efforts (Aoki 2000; Fiet 1994).

The venture capital firm's network position and its access to resources provide information that can help a new venture minimize the unpredictability of partner behavior (Gulati 2007). Venture capital affiliation can also reduce the risk of expropriation by increasing the cost of opportunism, as reports of a predatory partner will propagate throughout the network. The venture capitalist can also serve as an enforcement mechanism, punishing non-cooperative behavior by alliance partners. Established firms could be shut out of future deals, and in the case of private "within portfolio" deals where the venture capitalist has control rights, the management team could be directly disciplined. Finally, venture capitalists can also help to overcome the unknown quality and reputation of a new firm, which may keep collaborators from engaging in an alliance (Singh and Mitchell 1996). Findings suggest that endorsements from known affiliates, especially venture capitalists, can serve as a signal and certification of start-up quality and legitimacy (Megginson and Weiss 1991; Nicholson et al. 2005; Stuart et al. 1999).

However, the most important resource a venture capitalist can provide to a new firm is capital, as most of the other resources—including critical employees and technologies—can be bought (Davila et al. 2003). Therefore, the most straightforward approach to mitigating business, technology, or market risk would be to put more money into the firm rather than suffer the search and management costs of an alliance partner. Alliances take time to establish, and managing alliance partnerships will inevitably divert resources away from other activities and potentially constrain later strategic choices (Gulati 2007).

The ability of the venture capital firm to reduce transacting problems, along with its capacity to infer legitimacy, provides an explanation as to why venture capital firms may view alliance formation as a substitute for venture capital infusion. Our contention is that venture capitalists view alliance formation as a substitute for the infusion of capital, and we propose that:

H1 The number of strategic alliances formed by a venture-backed start-up is negatively related to the total amount of venture capital investment received by that portfolio company.

Networks figure prominently in venture capital investment. Venture capitalists tap a constellation of longstanding relationships to raise capital for investment (Lerner and Schoar 2005), to source deals (Shane and Cable 2002), and to support their development (Gorman and Sahlman 1989; Sahlman 1990). The syndication of venture capital investment is another important feature of entrepreneurial finance and a common practice amongst venture capitalists (Hochberg et al. 2007; Lerner 1994). Scholars have proposed that syndication reduces external risk, as venture capital firms can assess deals referred to them by other venture capitalists (Bygrave 1987) and the presence of multiple investors may also provide a signal as to the underlying

quality of the venture, limiting the number of poor-quality firms that receive funding (Lerner 1994).

Syndication may provide an additional benefit to the entrepreneurial firm from the perspective of alliance formation. Brander et al. (2002) find that the syndication of venture capital investment provides a wider range of value-added services to the portfolio through the complimentary management skills and shared social capital of the investors. Since different venture capital firms have different information, expertise, and network relationships, venture-backed companies may benefit from this enlarged pool of resources.

H2 The number of strategic alliances formed by a venture-backed start-up is positively related to the total number of venture capital firms investing in that portfolio company.

Venture-backed companies operate in product-market and technology environments characterized by high levels of dynamism and complexity. Eisenhardt and Schoonhoven (1996) propose that the strategic position of an organization will lead to the formation of particular alliance types.

The resource endowment of an organization (of which the venture capital firm is most certainly a part) influences its strategic decision-making process (Kraatz and Zajac 2001). Venture capitalists contribute to the venture capital firm through value-added activity and also provide a monitoring and disciplining role; they therefore represent a significant force with respect to shaping the strategic direction of a new venture (De Clercq et al. 2006). Of crucial interest to the venture capitalist post-transaction is the identification and mitigation of external, environment-related risk, primarily because the existing operational and contractual arrangements in the venture capital cycle are designed to mitigate internal risk, such as adverse selection and moral hazard (Fiet 1994). Lindsey (2008) finds that the propensity to ally is stronger for venture backed-firms with the intention of developing more in-depth research and development (R&D) or marketing alliances. We argue that venture-backed companies will choose different alliances in response to their product-market and technology environment and, drawing from the alliance taxonomy of Ghemawat et al. (1986), we detail our predictions for both, below.

2.1 Mitigating external market risk

Many venture-backed firms are engaged in the pursuit or commercialization of breakthrough technology. Firms such as these have advanced technological know-how but lack the marketing capabilities required to take the technology to market and to scale the firm to capitalize on the opportunity. Successful technology commercialization efforts require marketing resources, such as distribution channels, a known brand name, access to target customers, effective campaigns and promotions, etc. Marketing alliances can help firms access these crucial resources.

Highly competitive contexts are characterized by intense price and non-price competition, rapid and discontinuous changes in the market, and unpredictable competitor actions (Pfeffer and Selancik 1978). Competing in industry environments like these puts pressure on venture-backed firms to be able to reach their target customers effectively, secure an efficient distribution system, and be prepared to react to competitors' actions quickly. Venture-backed firms with limited resources and market experience need to form alliances to survive this fierce competition. Through cooperative product strategy, venture-backed companies provide complementary features for existing products, share an existing brand name, and leverage a service network, all of which help them access the customer base of their partners and mitigate the risks perceived by customers (Bucklin and Sengupta 1993). Hence, we propose:

H3 The number of marketing agreements formed by a venture-backed start-up is positively related to the level of environmental market competition.

2.2 Mitigating external technology risk

Many startup firms operate in a technological environment characterized by a high degree of uncertainty and the lack of a dominant design (Anderson and Tushman 1990; Arthur 1989). Despite the opportunities, startups have to search for breakthrough designs (Tushman and Anderson 1986)—and to do so relatively quickly in comparison to more established firms (Fiegenbaum and Karnani 1991). Innovative firms have very little margin for error and often lack the resources to radically change their

initial approach. Technology alliances enable such firms to pool resources, share risk, accelerate the development process, and shape the evolution and adoption of the dominant design.

When the technology environment is particularly unstable, a crucial success factor for venture-based firms is advancing the core technology and sharing the risk associated with its development. Technology alliances, including cooperation in research and development activities, provide those crucial resources. When the uncertainty in technology stems from the uncertainty in technological standard, technology alliances enhance the possibility for alliance partners to assist in the establishment of the dominant design. Previous studies have found that technology alliances are more beneficial in industries with rapid technological developments (Chan et al. 1997; Das et al. 1998). Hence, we propose:

H4 The number of technology-related agreements formed by a venture-backed start-up is positively related to the level of environmental technology instability.

3 Data collection and methodology

3.1 Data collection

We rely on two data sets to construct our sample. To investigate strategic decisions enacted by venture-backed firms to form inter-firm collaborations, we collected detailed information from the Thomson Financial SDC Platinum (SDC) VentureXpert database and Alliances database. VentureXpert is a private database of Venture Economics, which is a division of Thomson Financial. These data are used extensively in venture capital research (Gompers 1995; Hochberg et al. 2007; Hsu 2006; Lindsey 2008). They contain detailed venture financing information such as: (1) number of rounds of funding received; (2) average amount of funding received per round; (3) date of the first and the last round of funding; (4) number of venture capital firms involved; (5) founding date of the company. The SDC Alliances database covers comprehensive strategic alliances entered into by U.S. companies from 1988 onward (Anand and Khanna 2000) and records detailed information on various characteristics of alliances, such as the announcement date, contractual type, identities, and Standard Industry Classification (SIC) codes of alliance partners.

We match SDC VentureXpert and Alliances data sets by company name and Committee on Uniform Security Identification Procedures (CUSIP). We require that our sample companies receive their first investment from January 1 1992 to December 31, 2004. Since the SDC Alliance database starts its coverage from 1988, we use the time period from 1988 to 2008 to record alliance formation by sample companies. This time frame allows us to trace both existing alliances formed by our sample companies at the time they receive first venture financing and alliances formed after they receive first venture investment. After excluding companies with significant missing information, we obtain a sample of 1757 venture-backed companies, out of which 772 companies report sales information.[1]

Our basic sample is cross-sectional. While a cross-sectional data set can provide an overall view on how venture-backed companies form inter-firm agreements and how venture capitalists allocate financial resources, it cannot capture the dynamic effect of tradeoffs between two important resources from venture capitalists (e.g., capital infusion) and alliance partners (e.g., experience, distribution channel, and knowledge). Therefore, we construct a panel data set based on the companies in our basic sample, using the financing round as the unit of observation. This second sample contains 5896 financing rounds by 1757 unique venture-backed companies.

It is important to note that SDC VentureXpert database uses its own industry classification coding system—Venture Economics Industry Classification (VEIC)—rather than the SIC codes. To investigate the relationship among alliance activities, venture investment, and industry environment, we have to establish a linkage between the VEIC code and the SIC code. Following Dushnitsky and Shaver (2009), we match these two coding systems manually by reading the descriptions and other relevant company information.[2]

[1] We perform group mean tests to ensure that our sample companies are not significantly different from those companies dropped out because of missing accounting information.

[2] The authors gratefully acknowledge Dushnitsky and Shaver for their generous contribution of a conversion table linking VEIC codes and SIC codes.

3.2 Variable construction

3.2.1 *Measures of alliance activities and venture investment*

We collect information on the strategic alliance activities of our sample companies on marketing agreements and technology-related alliances (Hsu 2006).[3] We count the total number of strategic alliances entered by our sample companies, and the number of alliances for each sub-category. In addition to the count of alliances, we also follow Hsu (2006), taking a natural logarithm of the count of alliances in order to normalize the distribution.

For our basic sample, alliance information is collected at the aggregate level. We record both existing alliances before the first venture financing investment and alliances formed after the first venture financing investment. For the panel, we follow the same procedure to gauge alliance activities by our sample companies except that now our measures are round-specific. It is important to note that because not all information is available for every observation, the sample size varies across regression models.

Based on the information collected from SDC VentureXpert, we are able to calculate the total amount of venture capital and venture investment for each financing round received by portfolio companies and take the natural logarithm of these values to normalize the distribution of both variables. We also collect details on the total number of venture capital firms involved in the investment of a particular portfolio company.

3.2.2 *Measures of industry characteristics*

We are interested in industry-specific characteristics of the external environment. Therefore, the derivation of appropriate measures for certain industry characteristics is very important. Consistent with previous studies (Aldrich 1979; Dess and Beard 1984; Sharfman and Dean 1991), we attempt to develop objective measurements of industrial environment. Antecedent research identifies six environmental dimensions (Aldrich 1979), and with more recent research, reduces these environmental dimensions to constructs as environmental munificence, complexity, and dynamism (Dess and Beard 1984).

Environmental munificence measures the available resource that can support firms' sustainable growth (Hirsch 1975; Hofer 1975). Environmental complexity reflects the heterogeneity of organizations compositing for both inputs and outputs in an industry (Duncan 1972; Pennings 1975). According to the literature on organization theory and business policy theory, environmental dynamism captures the unpredictability and absence of pattern in a certain industry (Aldrich 1979; Pfeffer and Selancik 1978). Following Dess and Beard (1984), we employ use factor analysis to retrieve factors for environmental munificence and complexity from a set of variables collected from different sources.[4] From the U.S. Bureau of the Census we download annual surveys for different industries and economic census for the 1988–2004 time span to collect industry employment, payroll, establishment, shipment, revenue, and sales information. We use U.S. Bureau of Economic Analysis (BEA) input-output tables to obtain the inter-industry structure. Researchers have developed a number of variation-based indexes in industrial-level activities to measure environmental dynamism (Simerly and Li 2000). We regress industry values of shipment on a 5-year rolling base against time and use the standard error of the regression coefficient normalized by the mean value of industry's shipments as our index of environmental dynamism.

When venture capitalists and entrepreneurs make a joint decision, they may respond to the most relevant environmental pressure. Therefore, in addition to the overall industry environment, we focus on particular strategic choice and use relevant environmental dimensions in our analysis. In order to capture the market uncertainty, we use the average market share change over a 13-year period as a proxy. Demmert and Klein (2003) showed that "substantial changes in market share indicate high levels of competition." As a consequence, it is more difficult for entrepreneurial companies to penetrate a highly competitive market. We obtain market share information from the 1990, 1993, 1997, 1999, 2001, and 2002 editions of Ward's Business Directory, which ranked firms by sales

[3] We code R&D agreement, cross licensing agreement, and technology transfer agreements as technology-related alliances.

[4] See Dess and Beard (1984) for a detailed discussion of methodological issues.

within four-digit SIC codes. We manually calculate the market share change and firms presented in certain industries over the period in order to finally calculate the average market share change.

For the measurement of technology instability, Sharfman and Dean (1991) measure technological instability as the average number of patents in an industry. We suggest that this measurement cannot completely capture unpredictable changes, and build on the approach of Sharfman and Dean (1991) for measuring technological instability by using the standard error of research and development intensity (Snyder and Glueck 1982; Tosi et al. 1973):

$$\mathrm{RND}_t = b_0 + b_1 Y_t + \varepsilon_t, \quad (1)$$

where Y_t = time, RND = research development, and ε = residual

The industry R&D expenditure is regressed with year dummy variables from 1972 to 2002. We obtain the standard errors of the slope and then divide the standard errors by mean of industrial R&D. The use of standard errors as measures of instability is common to the environmental measurement constructs used by Dess and Beard (1984), Sharfman and Dean (1991), and Simerly and Li (2000). The standard errors capture the unpredictable change and, therefore, the higher the standard errors, the more difficult it is to predict the technological change.

3.2.3 Other control variables

Sharfman and Dean (1991) have proposed that geographic complexity is an important characteristic of industry complexity. In addition, venture investment is known to be clustered in certain regions (Chen et al. 2009). We control for geographic complexity to avoid the omitted variable problem in our regression analysis, employing two variables. The first is the geographic concentration of the number of firms, calculated as the sum of the number of firms in a particular in industry and census region divided by the total number of firms in the same census division squared. In a similar fashion, we also calculate the geographic concentration of the number of employees.[5]

Gompers (1995) documents that the nature of business may have a significant impact on the venture capitalists decision to release financial resources to their portfolio companies. We use the industry average market-to-book ratio and tangibility of assets to capture this effect. We match our sample with the COMPUSTAT database and calculate the industry median ratio of Q and asset tangibility (i.e., industry median market-to-book ratio and industry median tangible-assets-to-total-assets ratio) using information from firms with the same four-digit SIC code.[6]

We obtained the information about the age of the venture-backed company as a control variable. For our basic sample and panel data set, company age is calculated as the monthly difference between the company founding date and the date a company receives its first venture capital investment and corresponding round date, respectively. We take the natural logarithm to normalize the distribution of both variables.

In Table 1, we provide a summary of the statistics and pairwise correlation matrix of the variables we use in the regression analysis based on our basic sample.

4 Empirical results

4.1 Alliance choice and the structure of venture financing

We are interested in how venture capitalists view the broadened access to additional resources provided by alliance partners. Table 2 presents our results. We measure alliance activities of our sample companies by counting their alliance agreements. In the regression analysis, we use ordinary least squares (OLS) when the dependent variable is counts in logs (Hsu 2006) and report our results in columns 1–3. We use a negative binomial model when the dependent variable is nonnegative counts of alliance agreements and report our results in columns 4–6.

Since many of these resources could be bought (Davila et al. 2003), we predicted a negative

[5] For the sake of brevity, we only report our results based on the geographic complexity measured by the number of firms.

[6] We use industry median ratios to avoid a highly skewed distribution. We also use industry average ratios as a robustness check, and our main results do not change materially.

Table 1 Summary statistics of our basic sample and pairwise correlation matrix

Variable[a]	*n*	Mean	STD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Total alliances	1757	3.68	6.75	1.00														
2. Total marketing alliances	1757	0.64	1.47	0.88	1.00													
3. Total technology-related alliances	1757	3.04	5.49	0.99	0.82	1.00												
4. Venture capital investment in logs	1714	10.05	1.36	0.02	−0.05	0.04	1.00											
5. Total number of VC firms involved	1757	6.32	4.51	0.06	−0.01	0.07	0.63	1.00										
6. Company age in logs	1523	6.36	1.60	0.00	0.00	0.00	−0.27	−0.31	1.00									
7. Company sales in logs	772	9.89	2.22	0.26	0.20	0.27	0.07	−0.18	0.17	1.00								
8. Market instability	1366	0.07	0.16	0.02	0.05	0.01	−0.06	−0.05	−0.04	−0.02	1.00							
9. Technology instability	1366	0.06	0.02	0.04	0.01	0.05	−0.08	−0.05	0.09	−0.08	0.07	1.00						
10. Industry median Q	1734	2.52	0.97	0.02	−0.01	0.02	0.12	0.11	−0.01	−0.06	−0.19	0.22	1.00					
11. Industry median assets tangibility ratio	1734	0.19	0.14	0.00	0.02	−0.01	0.02	−0.01	−0.06	0.17	0.07	−0.40	−0.47	1.00				
12. Total past alliances in logs	1757	0.21	0.53	0.03	0.04	0.02	−0.28	−0.26	0.31	0.21	0.02	−0.02	−0.04	0.04	1.00			
13. Munificence	1366	−0.80	1.12	0.00	0.03	−0.01	0.00	−0.01	−0.07	0.05	0.76	−0.10	−0.34	0.39	0.03	1.00		
14. Complex	1366	−0.20	0.66	−0.04	−0.01	−0.05	0.07	0.06	−0.09	0.08	0.08	−0.79	−0.22	0.43	0.02	0.14	1.00	
15. Dynamism	1366	0.25	0.46	0.00	0.00	0.00	0.01	0.02	−0.03	0.05	0.06	0.09	−0.13	0.27	0.03	0.47	−0.22	1.00

VC, Venture capital

[a] Total alliances, total number of alliances entered by our sample companies after they receive their first venture capital investment; Total marketing alliances, total number of marketing agreements entered by our sample companies after they receive their first venture capital investment; Total technology-related alliances, total number of joint R&D agreements, cross-licensing agreements and technology transfer agreements entered by our sample companies after they receive their first venture capital investment; Company age in logs, the logged month different between a company's founding date and the date when it receives the first VC investment; Company sales, the logged sales revenue; Market instability, average market share change in a particular four-digit SIC industry; Technology instability, measurement of the unpredictability of R&D investment in a particular four-digit SIC industry; Industry median Q, industry median market-t-book ratio computed from Compustat; Industry median assets tangibility ratio, industry median tangible-assets-to-total-assets ratio computed from Compustat; Total past alliances in logs, logged total number of alliances before a company receives its first venture investment

Table 2 The structure of venture financing and choice of strategic alliances

Independent variable	Dependent variable: number of total alliance formation					
	OLS			Negative binomial model		
	DV: Number of alliance in logs			DV: Number of alliances in counts		
	(1)	(2)	(3)	(4)	(5)	(6)
Venture capital investment in logs	−0.0756**	−0.099***	−0.101***	−0.126***	−0.119***	−0.163***
	(0.0301)	(0.0335)	(0.032)	(0.0429)	(0.0428)	(0.0459)
Total number of VC firms involved	0.028***	0.032***	0.025***	0.038***	0.038***	0.042***
	(0.008)	(0.008)	(0.008)	(0.0132)	(0.0128)	(0.0135)
Company age in logs	−0.011	0.005	0.128**	−0.023	−0.020	0.003
	(0.018)	(0.019)	(0.040)	(0.0304)	(0.0302)	(0.0308)
Company sales in logs	0.109***	0.135***	0.119***	0.166***	0.169***	0.198***
	(0.016)	(0.020)	(0.019)	(0.0251)	(0.0261)	(0.0297)
Industry median Q		0.025	0.014		−0.029	0.034
		(0.037)	(0.036)		(0.0459)	(0.0595)
Industry median assets tangibility ratio		−0.423	−0.521		−0.888***	−0.394
		(0.347)	(0.321)		(0.3440)	(0.5203)
Total past alliances in logs		−0.007			0.014	0.039
		(0.081)			(0.103)	(0.112)
Munificence		0.026	0.027			0.041
		(0.036)	(0.033)			(0.044)
Complexity		−0.100*	−0.009			−0.191**
		(0.060)	(0.058)			(0.095)
Dynamism		−0.044	−0.127			−0.172
		(0.081)	(0.078)			(0.1129)
Inverse mills ratio			8.429***			
			(2.513)			
Constant	1.058***	0.939***	3.304***	1.169**	1.313***	0.997*
	(0.303)	(0.352)	(0.725)	(0.475)	(0.476)	(0.542)
n	691	681	515	691	681	532
F statistic	11.59***	7.65***	7.05***			
Adjusted R^2	0.078	0.092	0.1570			
Wald χ^2				45.93***	48.37***	64.99

***, **, and * indicates significance at the 1, 5, and 10% level, respectively

Robust standard errors are given in parenthesis

The above table reports regression results relating a venture-backed company's choice of alliance to the structure of its venture financing. Columns 1 and 2 use the number of alliances in logs as the dependent variable [estimated via the ordinary least square (OLS) model]; columns 3 and 4 use the counts of total number of alliances as the dependent variable (estimated using the negative binomial model). We require the sample companies to have sales information, which reduces our sample size

relationship between strategic alliances and total venture investment. The results presented in Table 2 strongly support this hypothesis. In all six specifications, the coefficients of venture funding are negative and significant at the 1% level. It is plausible that this relationship is purely a size effect. Larger firms tend to have more social connections, thus receive more venture funding; perhaps they also form more alliances. Thus, we enter sales in logs as a proxy for company size to obtain a more accurate estimation of the effect of venture capital investment on alliance formation. Because accounting information is not available for all sample companies, the addition of this sales variable substantially reduces the size of

our sample. However, the results generally indicate that strategic alliances are treated as a substitute to venture capital finance when venture-backed companies trade off between financial resources provided by venture capitalists and resources gained from alliance partners. Hence, we find support for our first hypothesis.

The involvement of more venture capital firms widens the scope of available network connections and provides more access to additional resources for portfolio companies. In this case, increased syndicate size can facilitate the identification of potential alliance partners and lower the search cost for portfolio companies. Therefore, we find support for our second hypothesis that the total number of venture capital firms involved is associated with the number of alliances formed by our sample companies.

It is possible that some venture-backed firms self-select into the strategy by employing alliances, which could potentially bias our findings.[7] To account for this possibility, we employ a two-step procedure outlined by Hamilton and Nickerson (2003) to correct for the potential endogeneity, constructing a matched sample of venture-backed firms that received venture investment but did not employ alliances. Following Hamilton and Nickerson (2003), we regress an indicator of using strategic alliances by venture-backed companies on a set of variables that can predict alliance choice in the first step regression. As we are focusing on marketing and technological alliances, we enter our measures of market instability and technology instability along with company age into the first step of the regression model. Based on the results, we can calculate the inverse mills ratio (Heckman 1979). In the second step of the regression (Table 2 column 3), we focus on the sub-sample of venture-backed companies that have formed alliances and perform ordinary least squares (OLS) regression analysis and insert the inverse mills ratio into the equation. This ratio is employed to detect selection in the sample, if any, and correct the error structures to obtain consistent estimates. We do find evidence of self-selection in our sample of venture-backed firms that employ strategic alliances. As the coefficient of the inverse mills ratio suggests, this group of companies negatively select into this strategy (Hamilton and Nickerson 2003). Such a negative selection may reflect the cost and risks associated with alliance building. However, correcting for endogeneity does not have any material change on our main results. We therefore conclude that our key findings are not driven by self-selection in our sample.

The analysis of the control variables also discloses some interesting results. For example, our proxy for company size, sales in logs, is positively associated with the number of alliances, which reflects the fact that large companies tend to have more alliances. We also control for general industry environment, namely environmental munificence, complexity, and dynamism. We find that environmental complexity is negatively associated with the number of alliances entered by our sample companies. Geographic complexity measures by establishment concentration and employment concentration are also positively related to strategic alliance activity. This aligns with a resource-based view of alliances; the likelihood of forming an alliance declines as the distance increases due to the increased difficulty of communication and resource exchange (Sorenson and Stuart 2001).

4.2 Robustness check for endogeneity

Even though venture capitalists tend to back companies associated with high risk but also high growth potential, portfolio companies are operating in different industry environments. Consequently, the tradeoff between the choice of alliance agreements and capital infusion can be quite different. In other words, the decision to use a combination of alliances and capital may be endogenous to a particular company. Unobservable firm effects can bias our estimation if they are omitted from the regression model. Thus, in a cross-sectional setting, making inferences about causality is difficult. To further explore this issue, we constructed a panel data set that tracks our sample companies over time.

Table 3 reports our regression results based on firm fixed-effect models along with year-fixed effects. Fixed-effects models are commonly used in this scenario to address the endogeneity issue induced by unobservable but time-invariant firm effects. We model venture capital infusion at each round as a function of existing alliances with a set of control

[7] We thank an anonymous referee for pointing out this possibility and for encouraging us to correct for the endogenity problem.

Table 3 Robustness check for endogeneity reveals regression results relating venture capital infusion at each financing round to the number of a company's pre-existing alliances before each financing round, using a panel of venture financing rounds

Independent variable	Dependent variable: venture capital investment in logs			
	(1)	(2)	(3)	(4)
Pre-investment alliances in counts	−0.073***	−0.014**		
	(0.013)	(0.006)		
Pre-investment alliances in logs			−0.279***	−0.134***
			(0.054)	(0.045)
Company age in logs		0.963***		0.987***
		(0.075)		(0.075)
Industry median Q		−0.048		−0.0501
		(0.046)		(0.046)
Industry median assets tangibility ratio		−2.500***		−2.458***
		(0.796)		(0.796)
Constant	5.134***	7.096***	5.038***	7.131***
	(1.131)	(0.230)	(1.133)	(0.227)
Year-fixed effects	Yes	Yes	Yes	Yes
Company-fixed effects	Yes	Yes	Yes	Yes
n	6535	5846	6535	5846
F statistic	46.39***	52.10***	51.10***	52.29***
Adjusted R^2	0.3359	0.3692	0.3353	0.3696

***, **, and * indicate significance at the 1, 5 and 10% level, respectively

For all regression models, robust standard errors are reported in parenthesis

In order to measure a company's pre-existing alliance activities, columns 1 and 2 use the counts of total number of pre-existing alliances, and columns 3 and 4 use total number of alliances in logs

variables. Columns 1 and 2 use alliance counts, and columns 3 and 4 use alliance counts in logs. Since we do not have sales information at the level of the financing round, we make the assumption that older firms tend to be larger and take a log of the age of the company as an implicit control for company size. Our results reveal that older venture-backed companies do receive more venture financing. Conditional on company age, venture capitalists do view capital infusion as a substitute to alliances as the coefficients across all model specifications are negative and significant.

Modern econometric theory points out that OLS regressions and White standard errors will be biased when the residuals are not independent (Petersen 2009). Simply using a fixed effects model will produce unbiased standard errors, but only when the firm effect is permanent. Moreover, the unobserved firm effect may change over the time. In this situation, the standard errors clustered by firm are unbiased whether the firm effect is permanent or temporary (Petersen 2009). In addition, adding year dummies into the empirical models can absorb economy-wide shock and control for the time trend. Therefore, we repeat our analysis in this section using clustered standard errors by companies and adding year indicators. In these robustness checks, we find results consistent with what we report here.[8]

4.3 Alliance choice and the external environment

In this section, we further explore the research question as to how venture capitalists help their portfolio companies to address environmental pressure through carefully choosing appropriate alliance partners. We are particularly interested in how venture-backed companies address the external market risk and technology risk through strategic alliances.

[8] For the sake of brevity, results based on clustered standard errors are not reported here, but they are available upon request.

Table 4 External environmental risk and the choices of strategic alliances

Independent variable	Dependent variable: number of alliances in counts			
	Negative binomial model			
	Marketing agreements		Technological agreements	
	(1)	(2)	(3)	(4)
Market instability	0.478**	0.323**	−0.031	0.071
	(0.002)	(0.001)	(0.001)	(0.001)
Technology instability	1.776	1.152	5.484***	4.281***
	(1.491)	(1.556)	(1.024)	(1.038)
Pre-investment marketing alliances	0.071***	0.087***		
	(0.019)	(0.028)		
Pre-investment technology-related alliances			0.012***	0.018***
			(0.003)	(0.004)
Company age in logs	−0.156***	−0.121***	−0.245***	−0.193***
	(0.030)	(0.026)	(0.019)	(0.018)
Industry median Q		0.146***		0.149***
		(0.028)		(0.022)
Industry median assets tangibility ratio		0.506*		0.302
		(0.252)		(0.183)
Constant	−0.273*	−0.729***	1.558***	1.070***
	(0.155)	(0.180)	(0.0971)	(0.120)
n	5534	4846	5534	4846
Wald χ^2	53.22***	56.84***	191.63***	176.25

***, **, and * indicates significance at 1, 5, and 10% level, respectively

For all regression models, robust standard errors are reported in parenthesis

The above table reports regression results relating a company's choice of alliances to its industry environment. Columns 1 and 2 use the counts of total number of marketing agreements as the dependent variable. Columns 3 and 4 use the counts of total number of technology-related agreements as the dependent variable. The negative binomial model is employed to perform the estimation because our dependent variables are non-negative counts

Table 4 presents our regression results of a negative binomial model relating the choice of strategic alliances (nonnegative counts) to the external industry environment (i.e., market risk and technology risk) of portfolio companies based on our panel data.

Columns 1 and 2 use the counts of market agreements as the dependent variable. We control for the number of pre-existing market agreements at each financing round, adding this variable to better detect the value-added role played by venture capital firms, as we are now testing the additional efforts made by venture capitalists to bring new alliance partners in order to address certain environmental risk. We also enter company age in logs, industry median Q, and the industry median asset tangibility ratio as control variables.

The results in columns 1 and 2 show that, conditional on pre-existing marketing alliances at each financing round, there is a significantly positive relationship between new marking agreements entered by our sample companies and market instability (i.e., average market share change in a four-digit SIC industry). This is the case that the number of pre-investment marketing alliances is positively associated with new marketing alliances. Combing the above findings, we demonstrate that venture capitalists make continuous efforts find alliance partners that mitigate market risk for their portfolio firms.

In Table 4, columns 3 and 4 use the counts of technological agreements as the dependent variable. We again enter the number of pre-existing technology alliances at each financing round along with other controls. We find that a significant and positive

relationship also exists between the choice of technology-related agreements and the technology instability, as predicted by our fourth hypothesis. When the technology development is difficult to predict, venture-backed companies tend to use more technology-related alliances to share the risk and expenditure in exploration untested means-end solutions. In addition, there is a positive relation between the number of pre-existing technology-related alliances and new technology alliances.

It is important to note that market instability (technology instability) has no explanatory power for the choice of technology-related agreements (marketing agreements). Therefore, our findings provide strong evidence that the choice of alliance partners is a strategic decision in order to address a specific aspect of the task environment (Dess and Beard 1984). Said another way: facing a turbulent and uncertain environment, venture capitalists support venture-backed firms by facilitating relationships that mitigate external risk.

An examination of the control variables is also illustrative. The age of a company is always negatively related to the dependent variables. This finding suggests that as a company matures and existing alliances accumulate, the need for an additional alliance partner decreases. The coefficient of industry median Q as a proxy for company growth potential has a significant positive sign. This finding strengthens our argument that at different financing rounds, venture capitalists add value by finding external partners to mitigate specific types of risk in an uncertain environment.

5 Summary and conclusion

Our study has examined the formation of alliances by venture-backed entrepreneurial firms. Our results provide novel insight on a value-added service that venture capitalists claim to provide—access to a rich network of alliance partners. Previous research demonstrated that venture capitalists promote within-portfolio alliances, with venture capital firms enacting significantly more alliances than a comparable set of non-venture-backed startups, and that venture-backed firms with more alliances tend to have higher IPO valuations. Incorporating the literature on strategic alliance formation, in particular the resource-based view of the firm, helps to explain why this is the case. Venture capitalists have both the motive (higher valuations) and means (professional networks) to help venture-backed firms forge alliances. Venture capital affiliation reduces both the cost and risk of a strategic alliance, shaping the trade-off between buying these resources or acquiring them through partnerships.

We suggest that alliances can be conceptualized as a substitute for capital infusion and that our empirical results provide support for this perspective. Our results document a negative relationship between the use of strategic alliances and the venture funding received by portfolio companies, and this finding is consistent with the broader perspective in the alliances literature (Davila et al. 2003). It follows from this perspective that by providing access to additional network connections and resources, syndication by venture capital firms is a way to share both risk and resources, thereby facilitating portfolio company growth. Our results compliment existing empirical work examining alliances in a venture capital setting (Lerner 1994) showing that venture-backed companies with more VC firms involved tend to have more strategic alliances. These findings suggest that enlarged syndicates do provide more access to additional resources.

Our results provide insight into the nature of the value-added services that venture capital investors provide. Our second set of hypotheses examined the nature of alliance formation in venture-backed companies. When venture capital-backed firms do engage in an alliance, what is the goal of that alliance? We empirically tested hypotheses on whether risk factors in the external environment—specifically, market competitiveness and technology instability—affect the alliance decision. Our results provide strong support that venture capital-backed firms leverage the network of their venture capital investors, and do so in a way that reduces firm-specific environmental risk. When the market competitiveness is high, more marketing agreements are announced. When the technology instability is high, more R&D and technology-related agreements are announced. Our findings suggest that entrepreneurial firms leverage the venture capital firm network to select partners to access resources most critical for them to form competitive advantage (Kraatz and Zajac 2001; Liao et al. 2003).

Entrepreneurs are willing to pay a premium to affiliate with a reputable venture capital firm because of the expertise and the network relationship they have (Hsu 2004). Our study lends additional support to this point of view, demonstrating the importance of alliance formation in addition to venture capital infusion. Future studies could examine whether more experienced venture capitalists or venture capital firms make better strategic decisions on how to choose alliance partners and on how these strategic alliances might affect the outcome and performance of venture-backed companies. Our study also provides an opportunity to contribute to the exploration of the performance differential between venture capital firms.

Recent work examining venture capital firm networks provides evidence of a link between better networked venture capital firms and the performance of startups. Our work illustrates one potential mechanism through which this performance is realized, and further suggests the intriguing possibility that better-networked venture capital firms can make more efficient use of capital under management, substituting alliance formation for capital where appropriate and, thus, having the ability to take startups to market for less invested capital than less well-networked firms. The implications of this perspective are significant for both theory and practice, and future work will examine this process in greater detail.

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