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CVC Investments and Technological Performance: Geographic Diversity and the Interplay with Technology Alliances

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Abstract

Although CVC strategies of firms have received increasing attention, extant research on the performance contribution of CVC investments has not explored the interplay between CVC investments and other mechanisms of knowledge sourcing in firms? broader knowledge sourcing portfolios. In this paper we examine the joint and interrelated effects on technological performance of firms? CVC investments and technology alliances. We argue that a wider geographic spread of CVC investments enhances knowledge sourcing potential by providing access to a greater variety of tacit and location-specific knowledge and research approaches. On the other hand, managerial and coordination complexities can undermine technological performance when a firm combines geographically diverse CVC investment and alliance portfolios. If firms concurrently pursue CVC investments and alliance activities in the same geographic locations, this may furthermore lead to knowledge sourcing redundancy. These negative interrelations can be mitigated if firms have instituted a specialized CVC unit to attenuate the coordination complexities and to facilitate selection of investment targets that complement firms? existing knowledge sourcing activities. Finally, we argue that a temporal sequencing strategy in which alliances precede CVC investments in a given location is advantageous. The improved status of the firm and greater knowledge of local managerial practice that arise from alliance activities can enhance the effectiveness of subsequent CVC investments. We find support for these conjectures in a panel data analysis of the technological performance of 165 firms in a broad range of manufacturing and technology intensive services industries.

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ABSTRACT

Although CVC strategies of firms have received increasing attention, extant research on the performance contribution of CVC investments has not explored the interplay between CVC investments and other mechanisms of knowledge sourcing in firms' broader knowledge sourcing portfolios. In this paper we examine the joint and interrelated effects on technological performance of firms' CVC investments and technology alliances. We argue that a wider geographic spread of CVC investments enhances knowledge sourcing potential by providing access to a greater variety of tacit and location-specific knowledge and research approaches. On the other hand, managerial and coordination complexities can undermine technological performance when a firm combines geographically diverse CVC investment and alliance portfolios. If firms concurrently pursue CVC investments and alliance activities in the same geographic locations, this may furthermore lead to knowledge sourcing redundancy. These negative interrelations can be mitigated if firms have instituted a specialized CVC unit to attenuate the coordination complexities and to facilitate selection of investment targets that complement firms' existing knowledge sourcing activities. Finally, we argue that a temporal sequencing strategy in which alliances precede CVC investments in a given location is advantageous. The improved status of the firm and greater knowledge of local managerial practice that arise from alliance activities can enhance the effectiveness of subsequent CVC investments. We find support for these conjectures in a panel data analysis of the technological performance of 165 firms in a broad range of manufacturing and technology intensive services industries.

Keywords: CVC investments, technology alliances, technological performance

INTRODUCTION

Recent years have witnessed a growing scholarly interest in Corporate Venture Capital (CVC) activities as an external knowledge sourcing strategy of established firms (e.g. Chesbrough & Tucci, 2004; Dushnitsky & Lenox, 2006; Keil et al., 2008; Schildt et al., 2005; Henderson & Leleux, 2002; van de Vrande, 2012). This has been against the background of a substantial increase in CVC activities over the last decade, driven by the emergence of new technologies and by the fact that CVC investments allow firms to quickly tap into external knowledge through a large set of boundary-spanning ties with new ventures that pursue pioneering technologies (Keil, 2002; Dushnitsky & Lenox, 2005, 2006). As CVC investments are usually small compared to firms' R&D budgets and are often carried out in stages, investments can be spread over a diverse array of new ventures, enabling access to a wide variety of resources and reducing risks (Allen & Hevert, 2007).

Several studies have illustrated that CVC activities contribute to firms' technological performance (Dushnitsky & Lenox, 2005; Wadhwa & Kotha, 2006; Keil et al., 2008; van de Vrande, Vanhaverbeke, & Duysters, 2011). In this paper, we contribute to this line of research by focusing on the importance of a geographically diversified portfolio of CVC investments for technological performance. Our focus on the geographic diversity of the CVC investment portfolio is informed by the fact that firms are increasingly establishing international linkages in order to access worldwide pockets of tacit knowledge (Hoffman, 2007; George et al., 2001). In this respect, studies on alliance portfolios have suggested that the geographic diversity of alliance partners enhances firms' technological performance by providing access to a greater variety of knowledge and by facilitating knowledge recombination (Lavie & Miller, 2008). Although CVC investment is amongst the most flexible of external cross-border knowledge sourcing strategies, there exists little prior research on the significance of a geographically diverse CVC portfolio for firms' technological performance.

In addition to CVC investments, established firms also employ other mechanisms, in particular technology alliances, for sourcing foreign knowledge (e.g. Lavie, 2007; Baum et al., 2000; Lavie & Miller, 2008). The extant literature has however paid little attention to the potential synergetic or detrimental effects of combining CVC investments and technology alliances as knowledge sourcing strategies. Prior studies that did examine performance effects of both alliances and CVC investments (Keil et al., 2008; Rothaermel & Hess, 2007; Van de Vrande et al, 2011; Wadhwa & Kotha, 2006) have juxtaposed alliances and CVC investments as potential performance enhancing strategies, without delineating the potential synergies or negative effects that their joint engagement could bring about. Other studies have taken a dyadic approach to examine whether and under what conditions existing CVC partners may become alliances partners (Van de Vrande & Vanhaverbeke, 2012; Sykes, 1990). A recent study by Dushnitsky & Lavie (2010) specifically examines potential tradeoffs between CVC investments and alliance formation, in an analysis of the propensity to engage in CVC investments by firms in the software industry. They suggest a complex balance between the two strategies, resulting from internal resource constraints, potential redundancy, and reputational and visibility effects.

In this paper we contribute to the CVC literature by examining the performance effects of CVC investments in relationship with their positive or negative interplay with technology alliances. We examine such tradeoffs or complementarities in the context of the benefits of geographic dispersion of these knowledge sourcing strategies. We build on prior work by highlighting that the value of a combined portfolio of geographically diversified alliance activities and CVC investments is negatively affected by the associated managerial complexities and the potential sourcing of redundant country-specific knowledge and expertise. We subsequently argue that the negative consequences of the interplay between the diverse portfolios of CVC investments and alliances can be mitigated if firms operate separate dedicated CVC units charged with coordinating CVC investments in the context of firms' wider knowledge sourcing needs. Finally, we argue that CVC investments and technology alliances can be mutually reinforcing if firms avoid simultaneous strategies and adopt sequential knowledge sourcing strategies in which CVC investments in a given location succeed prior alliance activities.

We examine these issues empirically by drawing on a panel data set on patents, CVC investments and alliances of a sample of 165 firms spanning a variety of manufacturing industries and selected knowledge-intensive services industries. In the following section we develop the theoretical background and the hypotheses of our study. This is followed by a discussion of the data, the variables and the empirical model. We then present the empirical results, and thereafter discuss the contributions of our study.

BACKGROUND AND HYPOTHESES

Over the last two decades firms have been increasingly adopting a globally dispersed knowledge sourcing strategy in order to tap into worldwide pockets of knowledge and innovation. External knowledge sourcing may minimize the cost, risk and uncertainty associated with the development of new technologies and can ease the pressure on firm's R&D resources, while speeding up the process of technology development (Mansfield, 1988; Chung & Yeaple, 2008). As a result of high environmental complexity and the rapid pace of technological change, firms increasingly achieve technological success not through the independent effect of a limited number of external relationships but through the combined effect of a portfolio of inter-organizational linkages (Hoffman, 2007; George et al., 2001; van de Vrande, 2012). Extending knowledge sourcing to multiple locations allows access to tacit knowledge components that are specific to the location and/or to the local partner firm and which are unlikely to diffuse easily outside the location. It increases the breadth of search and potentially allows for knowledge recombination and cross fertilization with positive performance consequences (Leiponen & Helfat, 2011; Lahiri, 2010; Ahuja & Katila, 2004). In the context of this increasing variety in the locations and mechanisms of knowledge sourcing, a growing body of literature has emphasized the importance of taking into account a firm's entire portfolio of external knowledge sourcing mechanisms for obtaining a clearer understanding of the opportunities and challenges that arise from simultaneous involvement in multiple and diverse relationships (e.g., Powell, Koput, & Smith-Doerr, 1996; Anand & Khanna, 2000; Parise & Casher, 2003; George et al., 2001; Hoffman, 2005, 2007; Lavie, 2007; Keil et al, 2008; van de Vrande, Vanhaverbeke, & Duysters, 2011; Belderbos et al, 2011).

In the empirical literature on the performance effects of external knowledge sourcing mechanisms, CVC investments have received attention only recently, with studies in general pointing to a positive contribution of CVC investments (e.g. Dushnitsky & Lenox, 2005; Wadhwa & Kotha, 2006; Keil et al., 2008; Van de Vrande, Vanhaverbeke & Duysters, 2011). CVC investments allow incumbents to acquire new knowledge created in entrepreneurial firms in a number of ways. Engagement in the due diligence process to assess a venture's technological attractiveness, resources, and operations allows the incumbent firm to learn about emerging products and technologies of a new start-up even before committing any resources (Chesbrough, 2002; Dushnitsky & Lenox, 2005). Additionally, incumbents can learn about the venture's key technologies and activities by taking a board seat, but also by facilitating and establishing interchange activities. The incumbent may establish organizational routines that facilitate smooth interaction with the start-up firms' personnel and to funnel learning from them (Daft & Lengel, 1986; Dushnitsky & Lenox, 2006). Finally, incumbents may even be able to benefit from failed venture investments if the technologies stay viable and feasible even after the venture's wind up (Hoetker & Agarwal, 2004).

Compared to CVC investments, technology alliances have been studied much more intensively. Extant literature has in general pointed to a positive impact of technology alliances on firms' technological performance (e.g. De Man & Duysters, 2005; Gulati, 1999; Mowery, Oxley, & Silverman, 1996). While both CVC investments and technology alliances are primarily mechanism to explore or search for emerging knowledge, both have their own distinct characteristics. Whereas technology alliances involve mutual knowledge development or knowledge exchange or both, and typically occur among established firms, in CVC activities technology development is almost entirely carried out by the target firm, with the CVC investor providing mainly the financial backing, as well as, in some cases, facilities for conducting R&D activities.

Although there is an expanding literature on the performance consequences of corporate venture capital investments and alliance portfolios, the performance effects of simultaneous engagement in these two technology sourcing modes have not received much attention. Prior studies that did examine performance effects of both alliances and CVC investments (Keil et al., 2008; Rothaermel & Hess, 2007; Van de Vrande et al, 2011; Wadhwa & Kotha, 2006) have treated CVC investments or alliances as a control variable without examining the interplay between the two knowledge sourcing strategies. As we will discuss below in greater detail, CVC investment and technology alliance strategies may interact in a number of ways and these interactions have major implications for the effectiveness of the combined portfolio of the two sourcing mechanisms. Maximizing their effectiveness by mitigating the tradeoffs between them can be facilitated by a distinct organizational structure as well as by inter-temporal sequencing strategies in which alliances precede CVC investments.

Hypotheses

CVC investments are an increasingly popular mechanism for accessing newly-created knowledge streams stemming from a range of partner (target) firms, each possessing its own distinct technological capabilities and research approaches. Given the low resource commitments associated with CVC investments, firms are able to invest in novel initiatives undertaken by a wide range of start-up firms (Hurry, Miller & Bowman, 1992; Dushnitsky & Lenox, 2006; Basu, Phelps & Kotha, 2011; Tong & Li, 2011; Allen & Hevert, 2007). While existing routines and practices of incumbent firms enhance their competence in deploying well-understood technologies more efficiently, they often hinder experimentation with novel technologies (Ahuja & Lampert, 2001). Even certain types of alliance activities that are carried out repeatedly with the same partners serve primarily to further and exploit firms' core competence (March, 1991; Teece, 1986; Koka, Madhavan, Prescott, 2006). In this context, a diverse portfolio of CVC investments potentially enables established firms to circumvent their organizational inertia that inhibits the development of new inventions, by allowing them to gain a foothold in emerging technologies and markets (Dushnitsky & Lenox, 2005; 2006).

Technologies exhibit a degree of geographic specificity because technological development is path dependent and tied to local institutions and their linkages with firms (Porter, 1990; Nelson, 1993; Cantwell, 1989; Feldman, 1993; Chung & Yeaple, 2008). Firms explore new sources of knowledge outside their existing environments by establishing linkages outside their traditional geographic regions, increasing the breadth of search and improving the effectiveness of technological capability development (Ahuja and Katila, 2004; Lahiri, 2010; Lavie and Miller, 2008). Access to diverse research approaches and tacit knowledge elements from around the world and combining this knowledge can be crucial for developing cutting edge technologies and creating first mover advantages. However, because technological knowledge is often embodied in the employees of local firms and tacit, acquisition of external knowledge without a local linkage is difficult (Winter, 1987; Kogut & Zander, 1995; Song, Almeida & Wu, 2003). Empirical studies support this view, suggesting that knowledge is sticky and seldom spills over beyond the geographic locations in which they are created (Jaffe et al., 1993; Mansfield, 1995; Saxenian, 1994; Verspagen & Schoenmakers, 2004). In this context, strategic technological alliances and CVC investments in entrepreneurial firms can help incumbent firms establish a local presence in foreign locations and thereby tap into location-specific, locally-embedded knowledge.

It follows that CVC investments in a number of geographic locations facilitate access to a range of location-specific knowledge and research approaches that can complement firms' existing knowledge base and provide exposure to new windows of technological opportunities. This leads to the following baseline hypothesis:

H1 (geographic diversity): Geographic diversity of the firm's CVC investments positively affects the firm's technological performance.

Simultaneous engagement in a diverse set of CVC investments and technology alliances creates a complex knowledge-sourcing portfolio, which may undermine effective management of the overall portfolio of knowledge sourcing activities. A firm's knowledge assimilation routines exhibit a certain degree of specificity with respect to the national, institutional and cultural backgrounds of its partners (Bruton, Fried & Manigart, 2005; Guler & Guillén, 2010; Nelson & Winter, 1982; Parkhe, 1993) and to the type of the inter-firm relationship (Dyer & Singh, 1998; Zollo, Reuer & Singh, 2002). Development of these routines is integral for successful knowledge acquisition because they reduce the transaction costs associated with the identification of the resource owners, the sharing of the tasks with the partners, the monitoring of the contract, and the settling of the disputes (North, 1990;

Parkhe, 1993; Gulati & Singh, 1998). Specifically, the knowledge assimilation routines for CVC investments are different compared to those for alliances. To gain from their investments in ventures, incumbent firms adopt such strategies as taking board membership in the venture, and entrusting managers to work as liaisons between themselves and the ventures (Keil, 2004; Dushnitsky & Lenox, 2006). These linkages with new ventures are aimed at ensuring early identification of technological opportunities and providing timely assistance to the ventures. Such mechanisms of knowledge absorption diverge from those in technology alliances, where there is a focus on gatekeeping roles (guarding outgoing knowledge flows) and explicit knowledge sharing (e.g. Das & Teng, 2000). The divergent decision rules and practices governing these two knowledge sourcing strategies create complexity in the overall knowledge management strategy of the firm.

If a firm invests in portfolios of both geographically dispersed CVC investments and technology alliances, effective learning requires that the firm develops routines that are both specific to each sourcing mode as well as to the variety of local environments. This combination of geographic diversity and sourcing mode diversity exacerbates managerial complexity in the development and deployment of specific routines and in coordinating, strategizing, and sharing experience on the commonalities and the differences between different geographic locations and partners types. Furthermore, since alliances and CVC investments require specific resource commitments and managerial attention for relationship building and knowledge sharing, increasing diversity with respect to both strategies can result in competition for the firm’s financial, technological and human resources (Dushnitsky & Lavie, 2010; Chesbrough, 2002; Dyer, Kale, & Singh, 2001; Schildt, Maula, & Keil, 2005; Wadhwa & Kotha, 2006).

Summarizing, combining geographically diverse portfolios of alliances and CVC investments creates substantial managerial and contractual complexity and is associated with competing resource claims. These features may lead to insufficient knowledge exchange among entities and lead to inadequate appropriation of expected benefits (Jiang, Tao, & Santoro, 2010; Goerzen & Beamish, 2005; Sarkar, Aulakh, & Madhok, 2009). It follows that expansion of diverse technology sourcing portfolios in both the CVC and alliance dimensions reduces technological performance benefits.

H2a (complexity): Simultaneous extension of the geographic diversity of both CVC investments and technology alliances negatively affects a *firm's* technological performance.

We argue that firms can mitigate the negative consequences of simultaneous expansion of diverse portfolios of CVC investments and alliances by organizing CVC activities in a specialized organizational unit. Building up specialized expertise in a separate CVC unit can enhance effective management of the CVC function and the adoption of effective knowledge sourcing routines (Dushnitsky & Lavie, 2010; Benson & Ziedonis, 2010; Dushnitsky & Shaver, 2009). The loose structures associated with the organization of venture activities in dedicated CVC units allow for a compensation policy that ensures that the firm is able to recruit and retain venture experts who are specialized in identifying promising investment opportunities, as well as in nurturing and tapping into their knowledge. Hence, a dedicated CVC unit is likely to enhance the managerial capabilities of the firm in utilizing and applying its external knowledge resources.

Instituting dedicated CVC units may also mitigate some of the coordination challenges in combining diversified alliance and CVC portfolios. The strategic motive of a CVC unit is often not restricted to identifying new windows of technological opportunities for the firm, but its mandate also often extends more generally to building on the firm's existing resources to develop new technologies (Hill & Birkinshaw, 2008). In this process CVC units maintain close relational ties with the top management of the parent firm and with the various business units of the firm such that their knowledge exploration activities complement the existing capabilities and the overall knowledge sourcing strategies of the parent (Hill & Birkinshaw, 2012; Gaba & Bhattacharya, 2012). Personnel of CVC units typically are those with years of experience in the venture capital business, have the necessary knowledge of venture practices and are in possession of decision rules and routines that are appropriate for effective utilization and management of ventures (e.g. Keil, 2004). Personnel operating a dedicated CVC unit therefore are able to not only effectively carry out due diligence processes, but also to act as effective liaisons between a firm and its venture, alleviating, in the process, some of the coordination challenges in combining diversified portfolios of CVC investments and alliance activities. This suggests that firms with a separate, professionally managed, CVC unit may be better able to coordinate between internal R&D programs and technology alliances activities and their CVC investments compared to firms that did not invest resources in professional CVC management.

A separate organizational structure also ensures that resources from CVC activities are not diverted to the firm’s R&D department and technology alliance activities, such that new and emerging technologies can be explored even if they may threaten existing technologies developed by the firm. Hence, if firms operate a CVC unit with dedicated R&D personnel and financial means, the claim on resources resulting from combining a diverse portfolio of CVC investments with that of alliance activities has a smaller toll on performance than in firms with a tight and integrated management structure. Loose organizational structures with dedicated CVC units therefore compare favorably with tight structures. In the latter, venture activities are organized and integrated in current business units and the internal R&D department screens CVC targets, performs due diligence, and monitors investments (Dushnitsky & Shaver, 2009).

The above arguments suggest that operating CVC units may allow firms to cope more effectively with the managerial complexity associated with the broad portfolio of technology sourcing strategies. This leads to the following hypothesis:

H2b (complexity mitigation): The negative effect on technological performance of simultaneously extending the geographic diversity of technology alliance portfolios and CVC portfolios is attenuated if firms operate a dedicated CVC unit.

A combined portfolio of CVC investments and alliances may also lead to sub-optimal outcomes if it generates redundant knowledge (Dushnitsky & Lavie, 2010). Firms' external knowledge sourcing strategies are investments under uncertainty (Arora & Gambardella, 1994; Kogut, 1991; McGrath, 1997) and may hold the promise of new exploitable technological opportunities. However, the value of a portfolio of knowledge sourcing strategies is reduced if these strategies lead to overlapping, redundant, knowledge. In that case, the value of the portfolio is lower than the sum of the values of the individual investments (Vassolo, Anand, & Folta, 2004; Mitchell, 1989; Dushnitsky & Lavie, 2010; Belderbos & Zhou, 2009).

In the context of geographically dispersed external knowledge sourcing strategies, redundant knowledge can result when a firm's knowledge sourcing portfolio consists of alliances and CVC investments in an overlapping set of locations. As both CVC investments and alliances may provide access to location-specific expertise and research approaches with localized tacit knowledge elements specific to a foreign country, alliances and CVC investments could be pursuing similar types of knowledge. Geographically overlapping CVC investments and alliances may therefore lead to redundant knowledge sourcing which diminishes the value of the combined knowledge sourcing portfolio.

It follows that simultaneous engagement in CVC investments and technology alliances in a similar set of countries runs the risk of generating knowledge redundancies that undermine technological performance. We propose:

H3a (redundancy): Overlaps in the geographic spread of CVC investments and alliance activities in the knowledge-sourcing portfolio of a firm have a negative effect on the *firm's* technological performance

Although redundant knowledge can result from simultaneous engagement in alliances and CVC investments in the same set of countries, firms with dedicated CVC units may be well equipped to better guard their technology sourcing strategies against redundant knowledge. In the context of the often broader mandate of a CVC unit to invest in emerging technologies that complement firms' existing R&D and technology alliances (Hill & Birkinshaw, 2008), coordination activities with the top management and the various business units may help reduce redundancy. The specialized expertise in dedicated CVC units may ensure that the firm is able to selectively tap into the knowledge streams emanating from its venture projects, filtering in only relevant knowledge and information and targeting complementary location-specific knowledge elements. This suggests the following hypothesis:

H3b (redundancy mitigation): The negative effect of the overlap in CVC investments and alliance activities on technological performance is attenuated for firms with a dedicated CVC unit.

In contrast to a simultaneous knowledge sourcing strategy, we propose that a sequential strategy in which alliance partnerships in a foreign country precede CVC investments in the same country could enhance, rather than diminish, the value of the combined portfolio. This is because a firm's prior alliance experience in a foreign country confers it the ability to identify the most desirable investment targets in that country, augments its local reputation and visibility as an exchange partner, and enhances its knowledge of the local business environment.

First, in line with a resource-based perspective, a firm's inter-firm alliance network confers it the ability to identify prospective partners and to assess their reliability, capabilities and strategic objectives before entering into rewarding partnerships and efficiently managing those relationships (Burt, 1992; Kogut, Shan & Walker, 1992; Gulati, 1995; Powell et al, 1996; Gulati, 1999; Ahuja, 2000; Eisenhardt & Schoonhoven, 1996). Such network resources are derived from intense and frequent interactions with other firms in the network that help build trust and facilitate the exchange of potentially rich and sensitive information among them (Krackhardt & Hanson, 1993; Gulati, 1995; Powell et al., 1996; Gulati, 1999). This counts even more in the context of cross-border alliances because of the greater difficulty there in gathering information regarding potential partners (Dyer & Singh, 1998) and because cultural and organizational differences between partners make international exchange relationships prone to greater distrust and conflict than domestic partnerships (Hamel, Doz, & Prahalad, 1989; Parkhe, 1993). Research has shown that international experience equips independent venture capitalists with the necessary skills to successfully negotiate the institutional constraints surrounding their investments in foreign countries (Guler & Guillén, 2010). Similarly, prior alliance activities in a foreign country may enable firms to adopt the best venture capital investment practices in the country (Gaba & Meyer, 2010). Hence, firms with prior alliance experience in a foreign country would have the necessary local knowledge to identify and invest in entrepreneurial firms that hold out the maximum potential and to more efficiently transact with them.

Second, alliance experience of corporate investors matters from the perspective of venture firms as well. Established firms with a proven track record in alliance activities carry greater appeal for new ventures compared to those lacking such a record. While knowledge misappropriation by partners is a concern for firms engaging in alliances (Kogut, 1989; Gulati, 1995; Gulati & Singh, 1998; Chung, Singh, & Lee, 2000) this is an even greater concern for entrepreneurial firms that seek corporate investment (Katila, Rosenberger & Eisenhardt, 2008; Dushnitsky & Lavie, 2010). In this context, embeddedness in an inter-firm network provides firms engaging in CVC investments greater local visibility and signals their reliability and reputation to potential future partners (Pfeffer & Salancik, 1978; Weiwel & Hunter, 1985; Baum & Oliver, 1991; Podolny, 1994; Eisenhardt & Schoonhoven, 1996; Ahuja, 2000; Dushnitsky & Lavie, 2010). Furthermore, one reason why new firms turn to corporate venture capital rather than to independent venture capital is to gain access to their established valuable social and professional networks (Teece, 1986; Stuart, Hoang, & Hybles, 1999; Dushnitsky & Lenox, 2006; Katila, Rosenberger, & Eisenhardt, 2008; Yang, Narayana, & Zahra, 2009). Hence, entrepreneurial ventures, particularly those that attract competition among CVCs for investment, would prefer a firm that has a credible alliance track record and has established its trustworthiness and reliability over a firm that lacks such proven partnership credentials.

In sum, alliance activity in a given country provides experience that is specific to the socio-economic environment of the country and may enhance the efficiency of subsequent CVC investments. Information flows from local alliance networks can enable a firm to effectively evaluate entrepreneurial firms and seize, in a timely fashion, investment opportunities in the most desirable ventures. At the same time, the reputation deriving from past alliances as a reliable and trustworthy partner makes the firm attractive to entrepreneurial firms. We therefore argue that the apparent tension between alliances and CVC investments can turn into a complementary relationship once alliances activities precede CVC investments:

H4 (sequentiality): A sequential strategy of carrying out CVC investments in a country following prior engagement in technology alliances enhances *firms'* technological performance.

METHODS, DATA, AND SAMPLE

Data and Sample

We test our hypotheses on a panel dataset, spanning the years 2001 through 2007, encompassing 165 leading firms in a broad spectrum of manufacturing industries and selected technology- intensive services industries (telecommunications and IT services). Firms were selected based on their manufacturing or service volume in the EU in 2007, and can have their headquarters in the EU or elsewhere. Most of the sample firms are based in the US (34), followed by Germany (26), France (21), the UK (19) and Japan (15). Five to eight firms are headquartered in small and internationalized economies such as The Netherlands, Finland, Switzerland and Sweden. Three firms (SAB Miller, in South Africa, and Tata Steel-Corus and SLI, in India) are not headquartered in an industrialized country. The firms operate in a wide range of industries and are roughly evenly spread across sectors.

For the sample firms we collected data on patent applications with the European Patent Office (as a measure of technological performance), information on technology alliances and CVC investments, and financial indicators such as R&D expenditures. Linking the patent applications to the 165 sample firms resulted in a total number of 186,117 patent applications over the sample period. To collect information on firms' venturing activity we used Thomson Financial's VentureXpert database. We retrieved the CVC investments by the sample firms and the information on the geographical location of the targets. In total 55 out of

165 firms (about 35% of the sample) made CVC investments during the investigation period. Among the CVC-active firms, the VentureXpert data indicated that 25 firms were engaged in CVC activities through a dedicated CVC unit. These firms split roughly equally between US and non-US based firms. For sample firms engaging in CVC investments, the average number of CVC investments is about three per year (with a maximum of 45), while for firms with a dedicated CVC investment unit this number is close to five investments per year.

We used Thomson's SDC Platinum database as well as the MERIT-CATI database to gather information about the alliance activities of the sample firms. It is well known that these sources of alliance data only overlap modestly (cf. Schilling, 2008). Therefore, combining complementary alliance information from the two databases strongly improves the accuracy of the alliance variables. We included only those alliances for which we had explicit information that technology development and technology sharing were among the objectives of the alliance. Specifically, we considered an alliance as technology alliance if it satisfied at least one of the following criteria: an alliance includes cross technology transfer—alliance in which more than one participant transfers technology to another participant or to the alliance; an alliance includes a research and development agreement; an alliance includes a cross licensing agreement—alliance in which more than one participant grants a license to another participant. We did not include joint ventures if these were not associated with technology transfer because joint ventures, more often than not, have joint production or marketing objectives rather than the pooling of R&D resources. Our primary source of financial data on the firms was Compustat, subsections North America as well as Global. In total, the panel includes 1,119 firm-year observations for the 165 firms.

Dependent variable – Technological performance

Following prior research on the technological performance implications of alliance and CVC activities (Dushnitsky & Lenox, 2005; Wadhwa & Kotha, 2006; Sampson, 2007;

Keil et al., 2008), we use patents as our technological performance measure. There are numerous advantages in using patent indicators as measures of firms' technological activities (Pavitt, 1985; Basberg, 1987; Griliches, 1990). Patent data are available in a consistent and longitudinal manner and provide 'objective' information in the sense that patents have been processed and validated by patent examiners based on novelty and utility of use. In line with previous studies we used the patent application date as the first indication of new capabilities and invention (e.g., Schmookler, 1966; Sampson, 2007). Our analysis controls for industry and firm-specific differences in the propensity to patent.

For each firm we collected data on patents filed at the European patent office for the years 2000-2007. We constructed patent datasets of firms at the consolidated level, i.e. all patents of the parent firm and its consolidated (majority-owned) subsidiaries were collected. For this purpose, yearly lists of consolidated subsidiaries included in corporate annual reports, and 10-K reports filed with the SEC were used. The consolidated subsidiaries are in almost all cases majority owned. The consolidation was conducted on an annual basis to take into account changes in the group structure of the firms over time. Using consolidated patent data is important since a substantial share of firms' patented inventions are developed and applied for in firms' subsidiaries. On average, close to 20 percent of the sample firms' patents use a subsidiary name or a variant of the current parent firm.

Hypothesis-Testing Variables

Geographic Diversity of CVC investments: In constructing firms' CVC portfolios we assume that all CVC investments made by the focal firm within a three-year window constitute its CVC portfolio. CVC investments have been found to affect firm's innovativeness for about three to four years after the investment activity (Dushnitsky & Lenox, 2005). We distinguish CVC investments by the geographic origin of the targets and compute the geographic diversity of the CVC investments, D_{CV}, as 1 minus the Herfindahl concentration index of the of CVC targets' countries of origin (e.g. Goerzen & Beamish, 2005, Sampson, 2007; Tallman & Li, 1996). Formally this can be expressed as:

$$D_{cv} = 1 - \sum_{j \in L(t)} \left[\sum_{t-3}^{t-1} cv_{j,t} / CV_t \right]^2$$

where $cv_{j,t}$ refer to the number of CVC investments of the focal firm in country j at time t, L the total number of CVC target countries, and CV the total number of CVC investments. CVC investments are measured for the three years prior to the measurement of the dependent variable (t-3 through t-1). The diversity index range includes zero (when CVC investments cover only one partner country) and can approach one (when CVC investments are equally spread over a large number of countries). Hypothesis 1 predicts a positive effect of the geographic diversity of CVC investments.

In order to test hypotheses 2a and 2b, the variable capturing complexity in technology sourcing strategies is constructed as the Euclidean distance between geographic diversity of CVC investments and technology alliances: $complexity = \sqrt{D_{CV}^2 + D_{TA}^2}$. This specification reflects the effects of simultaneous expansion of geographic diversity in the two knowledge sourcing strategies. It is (close to) zero if a firm has no diversity in either CVC or alliance portfolio (both D_{TA} and D_{CV} are at, or close to, zero) and approaches its maximum (the value 1) when both the CVC and technology alliance portfolio diversity reach their maximum value (D_{TA} and D_{CV} are close to one). Hypothesis 2a predicts a negative impact, as firms that simultaneously increase the diversity of their CVC investments and technology alliance activities face greater coordination tasks and managerial complexity. Hypotheses 2b is tested by examining the impact of complexity separately for firms that operate a dedicated CVC unit and firms that do not operate such a unit, and predicts a mitigated influence for the former.

Redundancy in technology sourcing (hypothesis 3a and 3b) is constructed as the geographic overlap in CVC activities and technology alliances. We computed the extent of co-location between the firm's CVC investment targets and its technological alliance partners using Jaffe's proximity measure (Jaffe, 1986; Sampson, 2007, Ahuja & Katila, 2001). We calculated the distribution of each firm's CVC investment targets and alliance partners across countries, captured by the vectors $CV = (CV^1, \ldots, CV^k)$ and $TA = (TA^1, \ldots, TA^k)$. Each element of the vectors CV and TA is the number of CVC investment targets and alliance partners, respectively, in t-1 to t-3, of the focal firm that are located in a country k. The extent of co-location between CVC and alliance activities is calculated as:

$$P = CV.TA' / \sqrt{(CV.CV')(TA.TA')}.$$

This overlap or redundancy measure ranges from 0 (no redundancy) to 1 (complete redundancy). Hypothesis 3a suggests a negative overall effect of redundancy. Hypotheses 3b is tested by examining the impact of redundancy separately for firms that operate a dedicated CVC unit and firms that do not operate such a unit, and predicts a mitigated influence for the former.

Hypothesis 4 is tested by including the variable sequential technology sourcing. This variable is constructed as the geographic overlap in past technological alliances and subsequent CVC activities. Using the Jaffe proximity measure as before, we computed for each firm in our sample the extent of co-location between its technological alliance partners in years t-4 to t-6 and its CVC investment targets in years t-1 to t-3. Hypothesis 4 predicts a positive effect.

Control Variables

The analysis controls for the geographic diversity of technology alliances. The geographic diversity of technology alliances, D_{TA}, is constructed in a similar way as the diversity index for CVC investments, i.e. as one minus the Herfindahl index of concentration of alliance partners' countries of origin:

$$D_{TA} = 1 - \sum\nolimits_{j \in L(t)} \left[\sum\nolimits_{t-3}^{t-1} ta_{j,t} / TA_t\right]^2.$$

Here too we adopted a three-year window in line with earlier studies (Gulati, 1995; Lavie & Miller, 2008), and assume that all ties formed by a focal firm within this time window constitute its alliance portfolio. In identifying the geographic origin of the partners we take the location of the participant-partner in the alliance, irrespective of whether this partner is independent or part of a larger group or ultimately owned by a parent firm based in another country (cf. Erramilli, 1996, Kogut & Singh, 1988, Makino & Beamish, 1998). We take this focus because it can be assumed that the technological capabilities and local embeddedness of the direct partner firm are most important in the alliance.

The empirical models use firm fixed effects to control for firm heterogeneity in technological performance, as well as control variables for time varying firm-level factors that are likely to affect such performance. Firm-level controls include the value of the consolidated R&D stock in year t-1, constructed using perpetual inventory method assuming a depreciation rate of 15% to account for variations in inputs into the R&D process (e.g. Hall, Mansfield, & Jaffe, 1993), and the ratio of the lagged patent stock (also constructed using perpetual inventory method) to the R&D stock in order to capture differences in the propensity to apply for patents (e.g. Blundell et al., 1995). General inter-temporal trends in patenting behavior are controlled for with year dummies.

The remaining controls are included to ensure that the variables related to geographic diversity indeed measure the impact of such diversity and do not reflect the influences of other factors such as technology diversity or the simple scale of technology sourcing activities. Using SDC SIC codes and technology class information in the CATI database, we derive the variables technological diversity (CVC) as the number of unique technology sectors of the focal firm's CVC targets and technological diversity (alliances) as the number of unique technology sectors of the firm's alliance partners, both as a proportion of the total number of CVC investment targets and alliances in the portfolio, respectively. We also control for the size of the technology sourcing portfolios and include the number of CVC investments and technology alliances in which the firm has engaged; the variables technology alliance portfolio and CVC investment portfolio respectively measure the number of technology alliances and the number of CVC investments of the firm in the years t-3 through t-1.

Methods

The empirical model relates the technological performance measured by the number of patent applications of the firm in a given year, to prior CVC and technology alliance activities of the firm, controlling for R&D and other firm and environmental features. The dependent variable is a count variable. Our preferred model is the more efficient negative binomial specification. Hausman tests showed systematic differences in the estimated coefficients of the negative binomial model with fixed versus random effects ($Chi^2 = 142.49$; p-value < 0,01), such that the fixed effects model is preferred. In this model, the individual fixed effects control for unobserved heterogeneity in firm characteristics, such as general managerial capabilities, that could affect technological performance.

EMPIRICAL RESULTS

Table 1 provides descriptive statistics. The sample firms on average apply for 170 patents per year. Among firms reporting alliances and CVC investments, the average alliance portfolio consists of 19 alliances, while the average CVC portfolio consists of 14 investments. The largest portfolios of alliances and CVC investments in our sample count 81 alliances and 100 CVC investments, respectively. The geographic diversity of CVC investments is relatively small at 0.19, while it is higher for alliances, at 0.57. The geographic overlap between CVC investments and alliance activities (redundancy) is relatively high: 0.7 on a 0-1 scale. The inter-temporal overlap (sequentiality) is only a notch lower, at 0.68.

The correlations table focuses on 'within' correlations between the variables (correlations between the variables at the firm level but not in the cross section dimension) reflecting the fact that our analysis examines the within-firm variation over time in technological performance. While correlations are moderate in most cases, there are a number of exceptions. This naturally includes the correlation between complexity and its constituent variables CVC diversity and technology alliance diversity. Another exception is the correlation between concurrent overlap in CVC and alliance portfolios (redundancy) and sequential overlap (sequential technology sourcing). In this case, we show that any estimated effect of these two variables is not due to potential spurious correlation, by also estimating models with only one of these variables included.

Insert Table 1 about here

Table 2 reports the empirical results of the fixed effects Negative Binomial regression models of the relationship between CVC investment portfolio diversity, redundancy and complexity in technology sourcing and the technological performance of firms. Model I includes only the control variables and serves as a point of comparison for the remaining models in which we sequentially add the main variables for testing the various hypotheses. The likelihood ratio tests indicate whether each model extension is a significant improvement over the previous one, with the final, full hypotheses testing model providing the best statistical fit of the data.

Results from the basic specification with only controls included show the expected positive signs for the geographic diversity of alliances, R&D stock and the patent to R&D ratio. In line with prior findings on the general positive effect of CVC investments (e.g. Dushnitsky & Lenox, 2005) and technology alliances (e.g., DeMan & Duysters, 2005), we find that the size of the CVC investment portfolio and that of the technology alliances portfolio have a significantly positive effect. In contrast, the variables controlling for the degree of technology diversification of the CVC investment portfolio and that of the alliance portfolio are both insignificant. The geographic diversity of alliances has a positive and significant impact, in line with prior findings in the literature (Lavie and Miller, 2008; Belderbos et al., 2011).

Insert Table 2 about here

When the geographic diversification of CVC investments is added (model II) its coefficient is positive, but just not significant. However, in subsequent models that contain the complexity of the knowledge-sourcing portfolio (Model III) or all of the hypotheses testing variables (Model VII), geographic diversity of CVC investments has a significantly positive coefficient. These results lend support to our baseline hypotheses 1 that by broadening the geographic diversity of CVC activities firms can enhance their technological performance. As Model III reveals, the coefficient of the variable measuring complexity in knowledge sourcing strategies is negative and significant. When we split this coefficient (Model IV) between firms that have a dedicated CVC unit and those that do not (‘Complexity - Dedicated’ and ‘Complexity - Non-dedicated’) we observe that the size and significance of the complexity coefficient varies depending on this distinction. The coefficient of the variable ‘Complexity – Dedicated’ is insignificant (with the exception of model V) and lower in magnitude than that of the variable ‘Complexity - Non-Dedicated’. This suggests that firms that operate a dedicated CVC unit are not as likely to experience negative consequences from extending the geographical diversity of their knowledge sourcing portfolios compared to companies without a dedicated CVC unit. These results provide qualified support for Hypotheses 2a and 2b, and imply that although increases in a firm’s portfolio of alliances and CVC activities can increase the cost, and reduce the effectiveness, of managing the combined portfolio, having a dedicated CVC unit can attenuate these negative consequences. We note that this support is qualified: although the coefficients on complexity for firms with a CVC unit are comparatively small and in most cases insignificant, the standard errors of the coefficients are such that tests cannot confirm statistical difference from the coefficients on complexity for firms without a CVC unit.

When redundancy (geographic overlap) in technology sourcing activities is added to the model (Model V), its coefficient is negative and significant in support of Hypothesis 3a, suggesting that technology alliances and CVC activities pursued in similar sets of locations lead to less effective knowledge sourcing portfolios. If we split the redundancy effect between firms with and without a dedicated CVC unit (Model VI and Model VII), the size of the coefficient is small and insignificant for firms that manage their CVC investments via a dedicated unit (Redundancy - Dedicated), while the coefficient is higher and significant for firms that do not operate such a unit (Redundancy - Non-dedicated). Again we note the caveat that the standard errors of the coefficients are such that statistical difference between the coefficients cannot be confirmed.

Finally, in Model VII, the variable measuring sequential technology sourcing strategy in which CVC investments follows alliances is added to the analysis. A positive and significant coefficient for this variable provides support for Hypothesis 4, while the other empirical results remain largely unchanged.

CONCLUSION AND DISUCSSION

Over the last decade CVC investments have become an attractive mechanism for firms to draw on novel knowledge from diverse partner firms and locations around the world. However, existing research on the performance contribution of CVC investments has not explored the significance of a geographically diversified CVC portfolio. Also, while a limited number of studies have looked into the interplay between CVC investments and other mechanisms of knowledge sourcing, in particular alliances, they too have not examined how the geographic dimension of the two strategies can generate mutually reinforcing or mutually weakening effects.

In this paper we examined the importance of a geographically diversified CVC investment strategy for technological performance, taking into account the interrelations between the portfolios of CVC investments and technology alliance activities. The empirical analysis employed a panel data set that is based on a sample of 165 firms spanning a variety of manufacturing industries and selected knowledge-intensive services industries during 2001-2007. The results suggest the general importance of a geographically diversified portfolio of CVC investments, and confirm our predictions on the interplay between the diversified portfolios of CVC investments and technology alliance activities. Specifically, we find that technological performance is undermined when a firm combines highly geographically diverse portfolios of alliances and CVC investments because of the managerial complexities that a combined portfolio of these knowledge sourcing strategies entail. Our results also support the notion that concurrently pursuing CVC investments and alliance activities in similar sets of geographic locations may lead to the absorption of redundant knowledge and hence to poorer technological performance. We find qualified evidence that a loose organizational structure in the form of a dedicated CVC unit can mitigate both these negative consequences. Finally, the results also affirm that the two strategies can be mutually reinforcing and complement each other if firms follow an inter-temporal sequencing strategy in which technology alliances precede CVC investments in each geographic location.

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Table 1 Descriptive statistics and pairwise (within) correlations for sample firms during 2001-2007

		Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
1	Patents	166.04	306.72	1										
2	Geographic diversity - CVC investments	0.19	0.22	0.05	1									
3	Geographic diversity – Alliances	0.57	0.24	0.04	0.02	1								
4	Complexity	0.64	0.24	0	0.64	0.69	1							
5	Redundancy	0.7	0.33	0.03	0.59	0.06	0.5	1						
6	Sequentiality	0.68	0.36	0.17	0.58	0.06	0.34	0.42	1					
7	Size of CVC investment portfolio	14.22	18.82	0.11	0.12	0.01	0.09	0.19	0.28	1				
8	Size of Technology Alliance Portfolio	19.25	15.68	0.2	0.01	0.02	0.01	0.09	0.1	0.08	1			
9	Technology diversification - CVC	0.03	0.11	0.09	0.05	0.02	0.05	0.24	0.16	0.17	0.06	1		
10	Technology diversification - Alliances	0.08	0.16	0.02	0.03	0.05	0.03	0.09	0.01	0.08	0.02	0.04	1	
11	Patents/R&D	0.46	2.04	0.1	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	1
12	Log(R&D)	6.9	2.22	0.01	0.01	0.04	0.02	0.03	0.02	0.03	0.06	0.03	0.04	0.39

Notes: Means and standard deviations of the alliance- and CVC-based variables are for firms that have positive values of CVC investments and alliances. Correlations are within correlations.

Table 2: Fixed Effects Negative Binomial Regression Analysis of Firms' Technological Performance, 2001-2007

	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Geographic diversity - CVC (H1)		0.026	0.128**	0.127**	0.074	0.067	0.126**
		(0.033)	(0.054)	(0.054)	(0.058)	(0.058)	(0.061)
Complexity (H2.a)			-0.188**				
			(0.076)				
Complexity - Non-dedicated (H2.b)				-0.215**	-0.216***	-0.222***	-0.207**
				(0.084)	(0.083)	(0.083)	(0.081)
Complexity - Dedicated (H2.b)				-0.147	-0.172*	-0.117	-0.160
				(0.092)	(0.092)	(0.100)	(0.100)
Redundancy (H3.a)					-0.118**		
					(0.054)		
Redundancy - Non-dedicated (H3.b)						-0.160**	-0.184***
						(0.064)	(0.063)
Redundancy - Dedicated (H3.b)						-0.039	-0.118
						(0.080)	(0.084)
Sequentiality (H4)							0.164***
							(0.054)
CVC portfolio size	0.004***	0.005***	0.005***	0.005***	0.005***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Alliance portfolio size	0.003**	0.003**	0.003**	0.003**	0.004***	0.004***	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Geographic diversity - Alliances	0.087**	0.088**	0.124***	0.124***	0.123***	0.123***	0.117***
	(0.037)	(0.037)	(0.039)	(0.039)	(0.038)	(0.039)	(0.038)
Technology diversity - CVC	0.044	0.049	0.033	0.037	0.070	0.065	0.032
	(0.074)	(0.074)	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)
Technology diversity – Alliances	-0.063	-0.062	-0.052	-0.051	-0.029	-0.023	0.000
	(0.061)	(0.061)	(0.062)	(0.062)	(0.062)	(0.062)	(0.061)
Patents/R&D	0.801***	0.802***	0.827***	0.826***	0.829***	0.829***	0.837***
	(0.038)	(0.038)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Log(R&D)	0.572***	0.573***	0.606***	0.605***	0.612***	0.607***	0.613***
	(0.033)	(0.033)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
Intercept	-0.502**	-0.533**	-0.768***	-0.760***	-0.739***	-0.708***	-0.776***
	(0.211)	(0.215)	(0.233)	(0.233)	(0.232)	(0.233)	(0.232)
Log-likelihood	-3638.79	-3638.486	-3635.391	-3635.098	-3632.738	-3631.904	-3627.299
-2⊿LL		0.60	6.19**	0.59	5.06**	1.92	9.21***

Notes: Standard errors in parentheses, * p<0.1, ** p<0.05, *** p<0.01. All models are estimated on a sample of 1123 obs for 165 firms, and include 6 year dummies.