Technological Diversification Through Corporate Venture Capital Investments: Creating Various Options to Strengthen Dynamic Capabilities

Simon U. Lee & Jina Kang

Published online: 15 Jul 2015.

Submit your article to this journal ⤤

Article views: 2386

View Crossmark data ⤤

Citing articles: 6 View citing articles ⤤

Routledge
Taylor & Francis Group

Research Paper

Technological Diversification Through Corporate Venture Capital Investments: Creating Various Options to Strengthen Dynamic Capabilities

SIMON U. LEE* & JINA KANG*,**

*Technology Management, Economics and Policy Program (TEMEP), Seoul National University, Seoul, South Korea,
**Department of Industrial Engineering, Seoul National University, Seoul, South Korea*

ABSTRACT   Corporate venture capital (CVC) investment in technology-intensive entrepreneurial ventures has attracted increasing attention from established firms which recognize it as a useful learning investment strategy to create diversified technological options for future change. However, there is a lack of empirical research which examines the relationship between CVC investment and the corporate investors' technological diversification. In this study, we investigate the effects of CVC investments on corporate investors' technological diversity by using 20 years of panel data from corporate investors in five high-tech industries. As a result, we find that the total amount of CVC investments and the industrial diversity of portfolio companies exhibit curvilinear (inverted U-shape) relationships with the corporate investors' technological diversity. Moreover, the empirical results show that the absorptive capacity of corporate investors positively moderates the effects of CVC investments on the technological diversity.

1. Introduction

Today's high-tech industries are characterized by a competitive environment and very short technology life cycles. These characteristics result in radical shifts of the technological paradigms (Schumpeter 1942; Arrow 1962; Nelson and Winter 1982). To survive and grow

Correspondence Address: Jina Kang, Technology Management, Economics, and Policy Program (TEMEP), Seoul National University, Seoul, South Korea. Tel.: +82-2-880-8386, Fax: +82-2-873-7229, Email: profkang@snu.ac.kr

in this changing environment, firms need to possess dynamic capabilities that enable them to utilize the diverse competencies and opportunities located both inside and outside of the firm boundary and proactively cope with changes (Teece, Pisano, and Shuen 1997). Since technological and market uncertainty are very high, however, the rapidly changing market conditions make it difficult for firms to forecast and prepare for upcoming changes in advance (Nelson and Winter 1982). Especially, the high risk of investing in emerging fields and new technologies, which are unrelated to the existing business, makes it difficult for firms to decide on a course of action to deal with the changes (Van de Vrande and Vanhaverbeke 2013)

To actively cope with this uncertainty and changing circumstances, established firms need to expand the diversity of their technological knowledge base (March 1991). This expansion allows the firms to have various options when responding to radical change of technological paradigms, and enables them to immediately select an appropriate reaction (Brown and Eisenhardt 1997). Through technological diversification, firms can open new windows on business opportunities and achieve both product differentiation and process innovation (Torrisi and Granstrand 2004; Pavitt 1998). Consequentially, securing diversified technological options strengthens the firms' dynamic capabilities and increases survivability during unforeseen and competitive environmental changes.

However, due to limited abilities, firms often find it difficult to create diversified technological options from their internal R&D activities alone (Henderson 1993; Tushman and Anderson 1986). Thus, many established firms try to acquire new and unfamiliar technologies from outside the organization via external learning investments (Janney and Dess 2004). Learning investment in external knowledge sources can be an efficient way to create multiple options for technology (March 1991). Before entering emerging markets and industries, through small investments, firms can test the waters and get prepared for the challenges ahead (Van de Vrande and Vanhaverbeke 2013). In light of this, learning investments in technologies in early stage can be a means to such option-creation activity as described in real option theory.

Among the different learning investments, corporate venture capital (CVC) investment is one of the possible ways to search for new technological opportunities. CVC investments are small equity investments of established firms in early-stage start-up companies (Dushnitsky and Lenox 2005; Gompers and Lerner 2000; Zahra 1996; Zahra and Covin 1995). Compared to other learning investment strategies such as M&A, joint venture, and strategic alliance, CVC investment is characterized by a high flexibility and low risk on investment. Hence, it is a more appropriate strategy for firms to learn about early stage technologies with high technological and market uncertainty (Benson and Ziedonis 2009; Van de Vrande and Vanhaverbeke 2013). Through CVC, with a relatively small amount of investment in various venture companies, firms can learn about technology and market beforehand and secure diverse strategic options that they can exercise in the future (Maula 2001). Moreover, once they identify the potential of the technology and market they invested in, the uncertainty will be reduced, and firms can make well-informed follow-on investments (Wadhwa and Phelps 2011; Benson and Ziedonis 2009; Van de Vrande and Vanhaverbeke 2013). In summary, by employing CVC investment to create a portfolio of multiple technological options, established firms can enhance their dynamic capabilities and rapidly advance into new technological fields.

Prior research on CVC investment and its strategic role have demonstrated that CVC investment helps to recognize destructive technological discontinuity (Maula, Keil, and Zahra 2003, 2013), enhance the innovation performance of the corporate investor (Dushnitsky and Lenox 2005; Wadhwa and Kotah 2006), and lead to follow-on investments (Benson and Ziedonis 2009; Van de Vrande and Vanhaverbeke 2013). However, the extent literature has not yet sufficiently examined the role of CVC investments as a search method for diversified option creation (Yang, Narayannan, and De Carolis 2014). Most literature that has dealt with the impact of CVC investment on the investor firm's innovation performance only focused on quantitative effects (Dushnitsky and Lenox 2005; Wadhwa and Kotah 2006). What is needed, is to empirically investigate whether CVC investments, especially the access to various external technologies and knowledge, have an influence on the diversity of the technological knowledge base, which helps to cope with market changes.

To fill this gap, in this study, we empirically examine the relationship between CVC investments and the investors' technological diversification. Specifically, based on the dynamic capabilities and ambidexterity frameworks, we attempt a logical explanation of how organizational learning through CVC investments contributes to multiple option creation. Our empirical analysis investigates the impact of the total amount of CVC investments on the corporate investors' technological diversification through analyzing patent class data. Furthermore, we investigate the influence of the industrial diversity of the investment portfolio on the corporate investors' technological diversification. Moreover, we hypothesize and test the moderating impact of absorptive capacity on both relationships as a means of ambidextrous firm strategies.

2. Theory and Hypotheses

2.1 Dynamic Capabilities, Ambidexterity, and Real Options

Today's market environment, with its radical shifts of technological paradigms, requires firms to identify changes and rapidly transform themselves to survive and grow further. Restructuring an organization in accordance with the changed circumstances as well as learning and developing new technologies, allows firms to quickly cope with radical changes. The research by O'Reilly and Tushman (2008) demonstrated that most companies which were operating for over 100 years had changed their business portfolio over time in accordance with the changing environments.

As an explanation for such ability to adapt to changing environments, Teece, Pisano, and Shuen (1997, 516) introduced and defined the concept of dynamic capabilities: "dynamic capability is the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments." In other words, firms have to simultaneously exploit the existing internal resources and market position to sustain incremental innovation, and explore the knowledge about new technologies and markets to cope with upcoming radical changes. Such capabilities are in line with the concept of ambidexterity which emphasizes the balancing between different learning activities: exploitation and exploration (March 1991; Duncan 1976; Eisenhardt and Martin 2000; Raisch et al. 2009; Tushman and O'Reilly 1996). Exploitation, focusing mainly on the enhancement of the efficiency and productivity of firm activity, deals with the utilization of the

existing technologies and resources. On the other hand, exploration is to search and acquire unfamiliar and novel technologies and resources, aiming at generating variation. Firms which can efficiently balance and pursue both exploitation and exploration activities at the same time are referred to as ambidextrous firms.

O'Reilly and Tushman (2008) state that from the viewpoint of corporate organizations, the ability to become ambidextrous is strongly linked to a firm's dynamic capabilities. Using a tripartite taxonomy of sensing, seizing and reconfiguring adopted from Teece (2007), they describe the required capabilities for a successful implementation of ambidexterity. First of all, firms needs to "sense" various opportunities and risk factors from rapidly changing market environments, which requires scanning, searching and exploration abilities. Employing sensing capabilities, firms can detect the indications of paradigm shifts in the market and identify various technological opportunities resulting from those changes. Second, firms have to "seize" these opportunities, which requires decision making and executing abilities to acquire and understand the knowledge of newly identified technological fields. Last, firms ought to "reconfigure" their resources and organizational structure to gain sustainable competitive advantage from new opportunities. Firms can develop their own knowledge by combining newly acquired technologies and existing assets. Following this step-by-step logic of dynamic capabilities allows established firms to create multiple strategic options.

For established firms in industries which heavily rely on technology, creating multiple options manifests itself in a diversified technological knowledge pool. A firm which possesses various technological options in diverse fields can respond to unpredictable market changes more "flexibly" (Kyläheiko, Sandström, and Virkkunen 2002; Kogut 1991; Sanchez 1993). The more alternative options, the more resources can be used for each cases. If the life cycle of the technology, that an incumbent firm currently focuses on, has almost reached the end and new technologies are rising, the speed of response to these changes may depend on how much preliminary knowledge about those emerging technologies the firm possesses (Brown and Eisenhardt 1997). In the long run, technological diversification is a critical issue directly connected to established firms' survival in high-tech markets.

However, it is very difficult for a single company to build up a highly diversified knowledge pool on its own (Henderson 1993; Tushman and Anderson 1986). Since the resources and capabilities of firms are limited, the diversity of technologies is also restricted (Hagedoorn and Schakenraad 1994). Furthermore, in most cases, a non-cooperating single firm's innovation would follow an existing technological trajectory, leading to a "Myopia of Learning" (Levinthal and March 1993). Thus, when firms attempt to diversify their business into new industries or seize new opportunities beyond their current technological boundary, it is more effective to explore external knowledge rather than fully relying on internal resources and capabilities (Henderson 1993; Tushman and Anderson 1986). For all those reasons, many established firms attempt to carry out explorative learning or distant search to overcome the limitations of internal R&D (March 1991; Nelson and Winter 1982) through different strategies, including mergers and acquisitions (M&A), technological alliances, joint ventures and CVCs (Schildt, Maula, and Keil 2005).

Among those various learning strategies, previous literatures that deal with the relationship between firms' learning from external sources and technological diversifications mostly focused on strategic alliances (Leten, Belderbos, and Van Looy 2007;

Giuri, Hagedoorn, and Mariani 2004; Leten, Belderbos, and Van Looy 2007; Mowery, Oxley, and Silverman 1998; Sampson 2007). Mowery, Oxley, and Silverman (1998) and Giuri, Hagedoorn, and Mariani (2004) examined the relationships between the firms' technological alliances and their internal technological profile diversity through empirical data analysis. In their analysis of the alliance data of firms in 27 different technological fields, Giuri, Hagedoorn, and Mariani (2004) confirmed a significant and positive relationship between the technological alliances with external partners and focal firms' internal technological diversification, showing that the firms' efforts in external learning impact their technological diversification.

2.2 CVC Investments for Creating Diversified Technological Options

In recent years, CVC investments in entrepreneurial new venture companies have gained popularity as an organizational learning strategy for established firms that attempt to approach various new technologies (Gompers and Lerner 2000; Keil 2004; Dushnitsky and Lenox 2005; Wadhwa and Kotha 2006). Established firms can create diversified strategic options for future changes by investing in various emerging technologies of target companies (Chesbrough 2002; Van de Vrande and Vanhaverbeke 2013). Maula (2001) also pointed out that CVC investment is a typical example of a strategic investment for option creation.

There are several factors that make CVC investments more appropriate for creating multiple options in highly uncertain technology markets than other organizational learning strategies such as M&A, joint venture, or strategic alliance. The first factor is the corporate investor's strategic objective. The main objective of CVC investments is identifying and valuing early-stage emerging technologies in start-up companies (Dushnitsky and Lavie 2010; Van de Vrande and Vanhaverbeke 2013). Corporate investors want to improve their ability to identify new technological opportunities through CVC investments. Moreover, the strategic objective of CVC investments may include taking "real options" on various new technologies by investing in a wider range of technologies than the corporate investor can conduct itself. Ernst & Young's "Global corporate venture capital survey 2008−09"[1] supports this argument. According to the survey results, "map emerging innovations and technical developments" and, "window on new market opportunities" are the most important objectives of CVC investments. A report of NIST (National Institute of Standards and Technology)[2] also shows similar results. According to the survey, about 65 per cent of CVCs stated that they invest for strategic value and most of those respondents choose "seeking new technological and business directions" and "providing window on new technology" as the most important strategic objectives of their CVC investments. These surveys show that among corporate investors, CVC investment is widely considered as a learning investment to search for new technologies of venture companies which are outside the corporate investors' technological boundaries. For example, Google Ventures, a CVC affiliate of global giant company Google, is investing in various technological fields such as health care, life

---

[1] G. Dushnitsky, M. Haemming, and D. Tharp 2008. "global corporate venture capital survey 2008−09: benchmarking programs and practices." Supported by Ernst & Young.

[2] I. MacMillan, E. Roberts, V. Livada, and A. Wang 2008. "Corporate venture capital (CVC): seeking innovation and strategic growth." Supported by NIST.

science and driverless car technologies instead of focusing on Google's primary fields of consumer internet services and mobile industries.

This strategic objective of the investor is one of the differences between CVC and strategic alliances and joint ventures. In the majority of cases, firms uses alliances to enable the joint development of new technologies and projects with qualified partners rather than for searching or identifying new opportunities (Benson and Ziedonis 2009; Dushnitsky and Lavie 2010; Van de Vrande and Vanhaverbeke 2013). In other words, if the competitiveness of potential partners and their technologies is not yet know, focal firms may not establish alliances and joint venture with them. In such situations, CVC investments are a more appropriate learning method for searching newly rising technologies and creating diversified options than strategic alliances and joint ventures.

The second factor that makes CVCs more suitable for creating multiple options is that the investment is more flexible and safer as compared to other learning strategies. Since CVC investment requires smaller equity investments than M&As and joint ventures, it is more suitable for investments with a high level of uncertainty (Benson and Ziedonis 2009; Van de Vrande and Vanhaverbeke 2013). Due to the risk of failure, firms cannot easily make a decision to invest large amounts of equity in emerging technological fields with a high uncertainty level. In M&A deals which require a large investment to buy a whole business and in joint venture agreements that involve a 50:50 quota investment with a partner, firms stand to lose a lot in case of a failed investment. In real option theory, for the investment in highly uncertain technological opportunities, many scholars emphasize the importance of using small initial investments for prior learning about that technologies before making the decision for large scale investments (Kogut 1991; Mitchell and Singh 1992; Vanhaverbeke, Duysters, and Noorderhaven 2002; Van de Vrande and Vanhaverbeke 2013). These small initial investments create "strategic options" that can be used in the future. Previous literatures states that CVC investment can act as an option creator (Benson and Ziedonis 2009; Van de Vrande and Vanhaverbeke 2013). A corporate investor can reduce the uncertainty level of target companies and their technologies by obtaining preliminary knowledge about them via CVC investments. If the uncertainty level is sufficiently reduced and the firm is able to decide that it is promising to invest in the technological field, it can "exercise" its options to pursue further investment in those technologies through more aggressive strategies such as M&A, joint ventures, and strategic alliances (Benson and Ziedonis 2009; Van de Vrande, Vanhaverbeke, and Duysters 2009; Van de Vrande and Vanhaverbeke 2013). Moreover, compared with other external learning strategies, CVC investment contracts are very flexible because they allow corporate investors to stop investment any time they want (Van de Vrande 2013). Consequently, the characteristics of small equity investments and flexible contracts make CVC investments very suitable for searching various technologies and creating multiple options.

The third factor is related to the characteristics of the investment target of CVCs. The nature of the target venture companies' knowledge pools is very suitable to diversified option creation. Technology intensive venture companies are passionate about innovation activities and possess a high technological potential, factors that make them great sources for established firms' explorative learning (Engel 2004). Since incumbent firms have their own fixed routines and processes which have been generated over the firms' lifetime, they often face difficulties in creating entirely new technologies. On the other hand, entrepreneurial new venture companies have a relatively flexible and free business culture,

contributing to the higher probability of creating more fresh ideas than established firms (Kotrum and Lerner 2000; Zingales 2000). Moreover, commonly, new venture companies tend to prefer emerging markets rather than traditional and mature markets. Since in emerging markets established dominant technologies rarely exist, the technological competition between players in the market is severe and the probability of fresh and innovative knowledge creation is very high (Shane 2001). Because of these three factors, corporate investors which conduct CVC investments can access various knowledge bases in new technological fields and create diversified technological options.

2.3 Amount of CVC Investments

In the section above, we discussed the factors that make CVC investments beneficial for incumbent firms' technological diversification. To realize these benefits of technological diversification, corporate investors have to access their target venture companies' knowledge pools. An important factor that effects this accessibility is the amount of equity investments. The larger the corporate investor's equity investment in portfolio companies, the bigger is the new knowledge stock that the firm can access (Dushnitsky and Lenox 2005; Keil 2002, 2004). Before investing, corporate investors usually undertake an exhaustive due diligence process to monitor and better understand the unfamiliar technological fields in which their potential investment targets are engaged in Dushnitsky and Lenox (2005) and Keil (2002, 2004). Dushnitsky and Lenox (2005) argued that if CVC investors increase their investment, they will conduct a more thorough due diligence and learn more from the process. Moreover, once the investment round has started, corporate investors can form equity-relationships with the target companies and in the process often obtain a seat on the firms' board of directors, or at least the authority to inspect the board. These opportunities provide them with more powerful observation rights and more in-depth knowledge of the portfolio companies' core technologies (Dushnitsky and Lenox 2005). Summing up, if an incumbent firm increase its CVC investments in new ventures, they can improve the accessibility of the target firms' knowledge pools which leads to an increased technology diversity.

However, increasing the amount of investments in CVC will not endlessly increase the corporate investors' technological diversity because their investment strategy might change according to the different stages of CVC investment. At the initial stage of undertaking CVC investments, a firm is more likely to place its investment priorities on the search for new knowledge and technology, because it is important to identify what kinds of technology exist. But, throughout the investment process, as the firm gains more knowledge about various technical fields, its investment pattern may evolve into concentrating its resources on specific knowledge that it finds to be directly applicable. The transformation of the investment pattern and the resulting concentration will result in a decrease of the technological diversity that a firm creates using the newly sourced knowledge. While the number of new technologies generated from an enlarged CVC investment will increase (Dushnitsky and Lenox 2005), the diversity might actually decrease as a result of the above mentioned process of decision-making and concentration.

Moreover greater investments in new venture companies sometimes disserve investors' internal R&D activities (Wadhwa and Kotha 2006). As a means of external learning method, investments in entrepreneurial venture companies would compete with
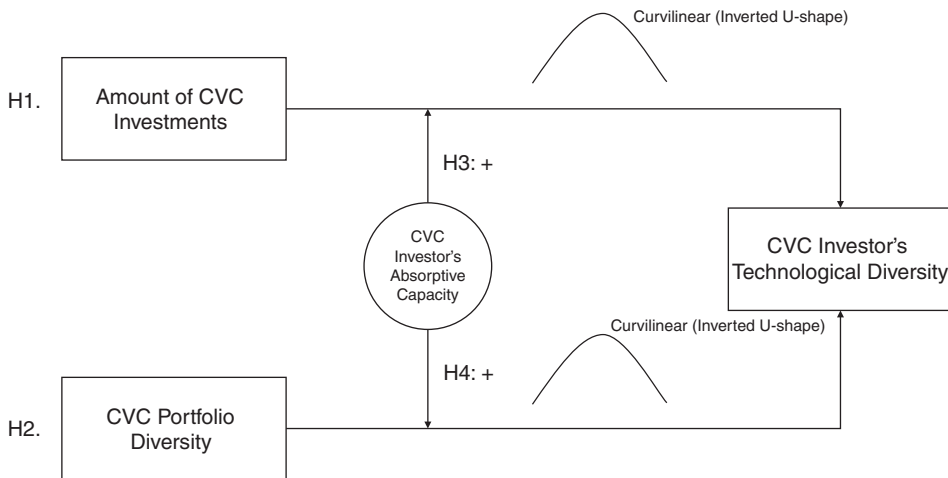
Figure 1. Research model

exploitative internal R&D activities for the same scarce organizational resources. This conflict relationship is a kind of trade-off between exploration and exploitation (March 1991). Thus, if a firm increases its investment in CVC, the proportion of resources that can be spent on internal R&D and exploration is necessarily reduced. When the portion of resources for internal R&D activities becomes excessively small, even though the volume of newly acquired external knowledge is increased, a firm's ability to generate actual innovation output by recombining new knowledge with existing knowledge could be severely impacted. As a result of such stagnant R&D production, the technological diversity of the investor's actual innovation output may also be reduced. This relationship highlights the potentially adverse impact of too much investments in CVC on the investor's technological diversity.

Altogether, these arguments suggest that to understand the relationship between the amount of CVC investments and the investor's post investment technological diversification besides the positive effects such as better access to the knowledge pool, also limitations stemming from a changing perspective and strategy on CVC must be considered. In other words, beyond some critical point, the positive relationship between the amount of CVC investments and the diversity of the investor's innovative output would change and exhibit diminishing characteristics. With these points in mind, we suggest the following hypothesis (Figure 1):

Hypothesis 1:   The technological diversity of a CVC investor firm has a curvilinear (inverted U-shaped) relationship with the total amount of its CVC investments.

2.4 Industrial Diversity of Portfolio Companies

One of the most important elements which impact on the technological diversification of corporate investors is the level of diversification of the portfolio. Usually, firms conducting CVC investments to find new technological opportunities do not only invest in ventures from a single industry, but rather follow a strategy that is quite similar to the diversified portfolio investment strategies in the stock market, which are an effective method of risk aversion

(Norton and Tenenbaum 1993; Markowitz 1952; Evans and Archer 1968; Jensen 1969). Investment in just a single specific technological field is too dangerous in an environment characterized by high volatility and high uncertainty.

In the previous research of Rosenkopf and Nerkar (2001) about establishing a firm's searching strategies, the authors argued that firms which attempt to reconfigure their knowledge should conduct distant search rather than local search and need to focus not only on organizational boundaries but also on technological boundaries. According to them, if a firm wants to create radical innovation, i.e. innovation that is very different from its presently available technology, widening the technological window to cover various and yet unfamiliar fields will yield better results than a local search confined to the fields already familiar to the firm.

The same argument can be applied to the explorative learning through CVC investments. While the actual investment strategy for CVC might vary depending on different intentions and goals of the investor, the effects on the investor's technological diversity are depending on the diversity of its present portfolio. If a firm focuses its CVC investments in a specific field, the firm could achieve a deeper understanding of that certain technology (March 1991). However, for a firm pursuing the objective of extending its technological boundaries, this strategy would have negative effects. Since companies in same industry usually have similar knowledge bases, it is possible that the newly acquired technologies from target companies in the same industry are overlapping each other (Breschi, Lissoni, and Malerba 2003). In other words, a focused investment in a specific technological field can be seen as exploitative learning to strengthen the depth of knowledge rather than as explorative learning for expanding the breadth of knowledge. Prior research on strategic alliances, another external learning strategy, also presented empirical results that support those arguments (Vassolo, Anand, and Folta 2004; Anand, Gardner, and Morris 2007). According to the results presented, if a firm enters an alliance with a company possessing an overlapping technology pool, the positive effects of the alliance partnership on the increase of the firms' knowledge base are minimal.

Enhancing the firm's technological diversity through investing into a wider scope of technological fields can prevent an established firm from becoming stuck on a predetermined technological trajectory and having problems adapting to changing environments. Diversity also allows the firm to have a wider vision of future development and prevents becoming trapped by an existing cash cow (Van De Vrande 2013). Increasing its knowledge in various fields, the firm can accomplish significant technological innovation in new fields. Technologically broad CVC investments can accelerate technological innovation and reduce the firm's risk in a high-uncertainty market environment.

However, more diversified investments in various industries do not only give rise to benefits but also to potential costs (Duysters et al. 2012). Increasing the industry diversity of the portfolio companies can put a strain on the investor firm's knowledge coordination capabilities. In prior research about firm's R&D strategy, it has been demonstrated that greater R&D diversification would lead to increasing coordination costs (Argyres 1996). Inordinate emphasis on diversified technology would result in an over-diversification problem which results in heavy costs due to the need to coordinate and integrate technological knowledge from various external sources (Lin, Chen, and Wu 2006). If the diversity of external knowledge source increases beyond a certain level, which is related to the investor firm's absorptive capacity, it will cause additional problems from information overload during the pre- and post-investment stages (Huang and Chen 2010; Wadhwa and Kotha 2006).

Moreover, this information overload can strain the cognitive capabilities of CVC investors (Wadhwa and Kotha 2006). When CVC investors attempt to select some specific technological fields from their portfolios as the key items for future competition, overly diversified portfolios can throw the investors into confusion. The complexity of selection is increased by too many choice alternatives. Under such circumstances, managers would find it increasingly difficult to recognize important and valuable information. This information overload problem can also prevent managers from handling information in a timely manner. Due to these reasons, many CVC investors fail to select promising ventures, which is one of the important reasons why established firms cannot gain the expected level of benefits from their CVC investments.

In addition, an excessively diversified portfolio will make supporting the portfolio companies during the post-investment stage more difficult. Unlike general venture capital (VC) investments, CVC investors are better suited to provide complementary resources and capabilities such as financial assets and internal R&D capabilities to the new ventures (Gompers and Lerner 2000; Dushnitsky and Lenox 2005; Percival and Cozzarin 2008). With this support, venture companies can better develop their technological potentials, and investors subsequently benefit from the increased value of their portfolios. However, if the industrial diversity of the portfolio is too high, the process of supporting becomes more complex and inefficient which leads to the potential of the venture companies not being fully realized. These drawbacks of excessively diversified portfolios, make it difficult for many CVC investors to translate the diversity of their portfolio into a diversity of their innovative outputs. Some literature about alliance portfolio diversity shows a similar relationship between the portfolio diversity and firm performance (Cui and O'Connor 2012; Duysters et al. 2012; Oerlemans, Knoben, and Pretorius 2013; Phelps 2010), but disagree in whether the alliance portfolio diversity has regular or inverted U-shaped relationship with the firms' innovation performance.

Taken together, these arguments suggest that the industrial diversity of portfolio companies has not only benefits but can also incurs costs, which effect the investor's post investment technological diversity. With increasing diversity, the positive relationship between the number of portfolio companies' industry background and diversity of investor's innovative output would impacted and show diminishing characteristics. With these points in view, we suggest the following hypothesis (Figure 1):

Hypothesis 2:   The technological diversity of a CVC investor firm has a curvilinear relationship (inverted U-shaped) with the industrial diversity of the ventures in its portfolio.

2.5 Absorptive Capacity and Technological Diversity

As discussed in the previous section, for companies seeking to increase the diversity of their technological knowledge base, CVC investments offer a range of benefits but also have inherent limitations. In other words, CVC investment into ventures in various industries will not necessarily, and will not always diversify the investor firm's technological portfolio. A firm's technological diversity is significantly depending on its ability to assimilate and apply the new information and technology. Even a firm with an abundance and variety of

information and technology from various external knowledge sources may not be able to create technological innovation if it fails to adopt and internalize these resources as its own.

This point of view can be explained by the notion of absorptive capacity. Absorptive capacity is the firm's ability to value, assimilate, and apply external knowledge (Cohen and Levinthal 1990; Zahra and George 2002). To realize technological innovation in various industries, investor firms need to assimilate the newly sourced external knowledge and apply it to their own internal knowledge (Grant 1996; Kogut and Zander 1992). This points out the fact that a firm's absorptive capacity can act as important factor in creating actual and diversified technological output. With the same amount of CVC investment, compared to a firm with a lower absorptive capacity, a firm with a higher absorptive capacity would be able to create a larger number and a larger variety of technological innovation. In similar fashion, with a CVC investment portfolio of the same level of industrial diversification, a firm with a higher absorptive capacity can adopt more diversified knowledge from those various knowledge sources and produce more technological innovation in various areas compared to a firm with a lower recombination capability.

This ability is also important in terms of the ambidexterity of the firm. Investor firm's internal absorptive capacity is closely related to its exploitation capabilities (Rothaermel and Alexandre 2009; Fernhaber and Patel 2012). Once an investor firm adopts external knowledge from a portfolio company into its own knowledge base, it becomes an existing knowledge. Assimilating and applying this knowledge is an activity of exploitation. As a notion of ambidexterity, a firm's innovative performance will increase when the firm conducts exploration (external learning, e.g. CVC investments) and exploitation (assimilation and application, e.g. internal R&D activities) simultaneously (March 1991; Tushman and O'Reilly 1996).

Hence, we can understand the role of the investor firm's absorptive capacity as positively moderating the correlation between its CVC investments and the firm's technological diversity. This logic applies to both the scale and the scope of the CVC investment, resulting in the following two hypotheses (Figure 1):

Hypothesis 3: A CVC investor firm's absorptive capacity will positively moderate the relationship between the total amount of its CVC investments and its technological diversity.

Hypothesis 4: A CVC investor firm's absorptive capacity will positively moderate the relationship between the industrial diversity of the ventures in its portfolio and its technological diversity.

3. Methods and Modeling

3.1 Data and Sample

We tested our hypotheses on a sample of large firms engaged in high-tech industries in the USA. Since firms in high-tech industries face a much higher level of uncertainty compared with firms from more traditional industries, we suppose that high-tech firms have more incentives to attempt explorative learning through CVC Investments. We carried out the selection and sampling of the data according to the following process:

First of all, we defined "high-tech industries" following the classification of the venture industries provided by the "Securities Data Company (SDC) Platinum Database". According

to Securities Data Company (SDC)'s definition, the following five industries are classified as "high-tech": "communication industry", "computer related equipment industry", "semiconductor/electric device industry", "biotechnology industry" and "medical/pharmaceutical industry" A total of 4928 U.S. firms active in those five industries had experience as CVC investors. In order to collect our sample of investor firms, we employed the ThomsonOne.com PE/VC Module Database. This database contains the same information as VentureXpert, a tool frequently used in existing studies on VC. It provides a list of CVC investor firms and also enabled us to collect investment round data to count the number of investment for each firm. Furthermore, since many investor firms established subsidiaries or independent funds for their CVC investments, we had to search by the name of subsidiaries and funds in online databases such as Lexis-Nexis DB to link them with their corporate parents. To investigate the investor firms' technological diversity, we used patent class data which is provided by the U.S. Patents and Trademarks Office (USPTO) database.

In this study, we considered CVC deals concluded in the 1990 to 2010 time period. During this period, a total of 40641 CVC investment deals were recorded, but among those, only 2917 deals of 267 investors could be matched to parent firms. For identifying the patent classes of CVC investors' patents, the International Patent Classification (IPC)'s 3-digit code was used. 154 out of 267 CVC investors appliedfor US patents during the period of the study. The data was supplemented with various financial information such as the firms' annual sales and R&D expenditures from the Datastream database. The industrial diversities of the portfolio companies were calculated using the ThomsonOne. com 4-digit Venture Economics Industry Codes (VEIC) while data on M&A and alliance deals was collected from the SDC database. Our final data-set contains 1313 firm-year observations from 97 different CVC investors but is unbalanced because of some missing data during the period.

3.2 Measures

3.2.1 Dependent Variable

The dependent variable in this study is the *Technological Diversity of CVC Investors*. As a proxy of technological diversification, CVC investor firm's patent application data was used. In several prior studies, patenting activity is used as a proxy to measure the rate of innovation (Ahuja 2000; Ahuja and Katila 2001; Dushnitsky and Lenox 2005). In particular, Wadhwa and Kotha (2006) used the primary technology class of CVC investor's patents to estimate the firm's technological diversity. Our study follows this approach by estimating a focal firm's post CVC technological diversity through the total number of primary (3-digit patent class code) technology classes in which it applied for a patent. However, since the application of a new technological patent generally takes one or more years from the beginning of the development of the technology, it is possible that patent applications immediately following the CVC activity are unrelated as they are the results of prior R&D efforts (Hausman, Hall, and Griliches 1984). To overcome this limitation, we use a cumulative lagged dependent variable of patent application data covering a 3-year time span from year t to year $t + 2$. Using such a cumulative lagged dependent variable also allows us the better show the temporal order of cause and effect.

3.2.2 Independent Variables

Our study makes use of three independent variables. The first independent variable is each investment firms' *Total Amount of CVC Investments* (in US Dollars). This variable is measured using a cumulative lag of three years—from year $t-1$ to $t-3$, in other words, for the analysis of the base year t, we calculate the sum of all CVC investment done in the three years prior to t. The differences in CVC investment of different firms and different investment rounds showed an exponential pattern, prompting us to use the natural logarithm when analyzing the data.

The second independent variable *Industrial Diversity of Portfolio Companies* shows how a focal firm spread its investments among venture companies in various industries. Using the 4-digit VEIC code and removing the duplicates, we counted the total number of industries invested into from year $t-1$ to $t-3$, and calculated the Herfindahl Index which is represented by the sum of squares of the investment proportion of each industry. The Herfindahl Index will have a value between 0 and 1, with a higher value showing concentrated investment rather than diversity. For convenience and easier understanding of the results, we want a higher value of our independent variable to signal a higher degree of diversity and thus the reciprocal of the Herfindahl Index was utilized (Leten, Belderbos, and Van Looy 2007).

$$\text{Industrial Diversity of Portfolio Compaines}_{(i,t-1\,\text{to}\,t-3)} = \frac{1}{\text{HI.Industry}_{(i,t-1\,\text{to}\,t-3)}}.$$

The third independent variable is the investor firm's *Absorptive Capacity*, which we expect to moderate the relationship between the two previous independent variables and our dependent variable. The *Absorptive Capacity* of companies is measured by focal firm's R&D intensity. Specifically, we calculated it as the R&D expenditure of focal firm i from year $t-3$ to $t-1$ divided by the firm's total asset size during the same time period (Cohen and Levinthal 1990; Lin et al. 2012).

$$\text{Absorptive Capacity}_{(i,t-1\,\text{to}\,t-3)} = \frac{\text{R\&D Expenditure}_{(i,t-1\text{to}t-3)}}{\text{Total Assets}_{(i,t-1\,\text{to}\,t-3)}}.$$

3.2.3 Control Variables

In addition to the quantity and quality of the CVC Investment, there are other parameters that can affect a firm's technological diversity, prompting us to add a number of control variables. First, we controlled for *Previous M&A Experience* and *Previous Alliance Experience*. External knowledge sourcing strategies other than CVC investments, such as alliances and M&As, are also important factors that can affect a firm's technological diversity. (Ahuja and Katila 2001). For instance, if a firm acquired a company which is operating in an industry that the investor firm has no experience in, it might obtain technology and thus future patents from a new class. Therefore we created two control variables measuring all strategic alliance and M&A deals conducted by the CVC investor firm i from the year $t-3$ to the year $t-1$. In the case of M&A deals, we only considered cases in which firm i acted as the acquirer to prevent a problem of data missing after firm i is acquired by another firm.

Next, the *Cumulative Patent Stock* of the firm can also affect its innovation capacity. The size of this variable indicates the extent of the firm's knowledge base and technological competence (Patel and Pavitt 1997). Firms with a larger cumulative patent stock have a larger absorptive capacity, which in turn enables them to have superior learning capabilities from external knowledge sources (Cohen and Levinthal 1990; Henderson and Cockburn 1996). Therefore we have to control for a CVC investor's cumulative patent stock to fully measure the impact of CVC investments on the firm's innovation activities. In this study, we defined the patent stock as the sum of the firm's patent applications in the five year period preceding the base year *t*.

Firm Size also can be a variable that, directly or indirectly, affects the innovation activities of firms. In general, larger firms find it easier to finance innovation enhancing activities such as R&D. Therefore we also controlled for firm size (firm *i*'s total sales in year $t - 1$).

Fixed Effects of Industry is an important variable that we need to control as different industries likely follow different trends related to technological diversification and have a different awareness of CVC investments. For example, in the case of the electric device industry, due to shorter technological life-cycles, the importance of new and creative technologies and ideas of venture startups is relatively higher than for other industries, which could raise the possibility of firms in this industry being more active in the pursuit of CVC investments. Therefore we control for the fixed effects of the five different industries in our sample by introducing dummy variables for each industry.

The final control variable in this study is the *Quality of Portfolio Companies*. Wadhwa and Kotha (2006) showed that the quality of the ventures in a CVC investor's portfolio can affect the subsequent learning performance. They controlled for this variable by using the total number of co-invested VCs for each round of investment. When VCs are involved in an investment, they perform stringent due diligence, so a larger number of VCs in an investment can indicate a higher investment value and quality of the venture-backed company. In this study, our control variable is defined as the number of VCs in each investment round that the focal firm *i* participates in.

For the control variables *Cumulative Patent Stock*, and *Firm Size*, the absolute value exhibited exponential differences, so again we utilized the natural-log exponential value.

3.3 Statistical Method

Technological Diversity of CVC Investors, the lagged dependent variable of this study, is a count variable which is calculated from the number of patent classes and does not have negative values. Thus, we decided to use a negative binomial regression model which is one of the nonlinear model commonly employed to avoid heteroskedasticity problems (Hausman, Hall, and Griliches 1984; Wadhwa and Kotha 2006). The negative binomial regression model is a generalized form of the Poisson model. Different from the normal Poisson model, which cannot be used when the standard deviation of the dependent variable exceeds its mean value, the negative binomial model can handle this case of overdispersion. Since the standard deviation of our dependent variable (135.089) is larger than its mean value (104.613), we chose the negative binomial model.

In the panel data of this study, some unobserved or unmeasured terms exist. To correct the heterogeneity problem stemming from these unobserved characteristics, fixed-effects and random-effects estimations can be used. At first, we conducted a Hausman test

(Hausman, Hall, and Griliches 1984) to check which estimation model is more appropriate. As a result of the test, the relationships between the property effects of each variable and the dependent variable of this study were statistically insignificant, thus random-effects estimation is more suitable for our panel data.

We assigned 1 year to 3 year time lags on most of our independent and control variables to obtain the cumulative effect of variables from the past years. Many prior researches that examine the influence of explorative learning such as the effects of CVC investment on the investors' patent output also used lagged variables (Ahuja and Katila 2001; Dushnitsky and Lenox 2005; Wadhwa and Kotha 2006) because it takes a substantial amount of time to assimilate and apply newly acquired external knowledge to create innovation output (Dushnitsky and Lenox 2005). Thus we also expect that CVC investment would only affect the investor's technological diversity after several years, prompting us to employ time lagged variables.

4. Results

4.1 Descriptive Statistics and Correlations

Table 1 represents the descriptive statistics of all the variables used in our study and the correlations between them. In case of the dependent variable, *Technological Diversity of CVC Investors*, the companies who performed the CVC investment applied for patents in an average of 104.613 classes. As this value is larger than the variable's mean value, as described above, we decided to use a negative binomial model for our analysis.

The correlation results between the variables of this study shows that *Total Amount of CVC Investments* and *Industrial Diversity of Portfolio Companies* highly correlate (correlation factor 0.545). This result could be one of the factors that give raise to a multicollinearity problem in the process of regression. In addition, the control variables such as *Cumulative Patent Stock* and *Firm Size* are highly correlated with the dependent variable. Especially, in the case of *Cumulative Patent Stock*, it turned out to be the most influential factor (correlation value of 0.771) on the patent class diversity of the investor firms. In case of *Quality of Portfolio Companies*, a high correlation with the *Total Amount of CVC Investment* and *Industrial Diversity of Portfolio Companies* can be seen.

4.2 Regression Results

Table 2 shows the results of the negative binomial regression model. For this study, we chose the random effects model. Model 1 is the unconstrained model which only includes the control variables on the condition of excluding the independent variables. Model 2 additionally includes the *Total Amount of CVC Investments* (Hypothesis 1) and *Industrial Diversity of Portfolio Companies* (Hypothesis 2) to test our Hypotheses 1 and 2. Model 3 and Model 4 identify the moderating effects of *Absorptive Capacity* with the *Total Amount of CVC Investments* and *Industrial Diversity of Portfolio Companies,* respectively. Lastly, Model 5 is our full model that includes all our variables.

Our Hypothesis 1 predicts a curvilinear relationship between the amount of CVC investment and technological diversity of the investor firm. In other words, we argue that as the company invests more resources on CVC, the diversity of the patent classes in which

Table 1. Descriptive statistics and correlations

Variable	Description	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9
1 Patents diversity i (t to $t+2$)	Cumulative count of patents classes newly applied for by focal firm in 3 years after CVC investment	104.613	135.089	0	627	1.000								
2 ln (CVC amt.) i ($t-1$ to $t-3$)	Natural log of total annual CVC investment in last 3 years	9.123	8.964	0	22.290	0.205	1.000							
3 Ind. diversity i ($t-1$ to $t-3$)	Inverse value of Herfindahl Index of portfolio companies' industry distribution in last 3 years	3.769	7.942	0	74.798	0.241	0.545	1.000						
4 ln (absorptive capacity) i ($t-1$ to $t-3$)	Natural log of cumulative R&D expenditure in last 3 years versus total assets in last 3 years	0.691	0.240	0	3.714	0.162	0.143	0.070	1.000					
5 M&A experience i ($t-1$ to $t-3$)	Cumulative experiences of M&A in last 3 years	8.713	10.747	0	85	0.328	0.328	0.477	0.045	1.000				
6 Alliance experience i ($t-1$ to $t-3$)	Cumulative experiences of alliances in last 3 years	18.571	35.475	0	339	0.323	0.025	0.144	0.046	0.447	1.000			
7 ln (patent stock) i ($t-1$ to $t-5$)	Natural log of cumulative patent stock in last 5 years	4.957	2.764	0	9.942	0.771	0.344	0.315	0.282	0.365	0.314	1.000		
8 ln (firm size) $i(t-1)$	Natural log of total sales in last year	8.279	2.235	0	12.184	0.528	0.226	0.282	−0.177	0.421	0.331	0.494	1.000	
9 Quality of portfolio companies i ($t-1$ to $t-3$)	Cumulative number of co-invested VCs in last 3 years	36.456	125.788	0	1792	0.215	0.358	0.623	0.069	0.400	0.107	0.241	0.211	1.000

Note: $n = 1{,}313$

Table 2. Negative binomial regression models (random effects model for CVC investor firms' technological diversity in t to $t+2$)

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
Independent variables										
ln (CVC amt.)$_{i\,(t-1\,\text{to}\,t-3)}$			0.143***	(0.031)	0.139***	(0.035)			0.127**	(0.046)
ln (CVC amt.)$_{i\,(t-1\,\text{to}\,t-3)\text{squared}}$			−0.018***	(0.005)	−0.015***	(0.004)			−0.027**	(0.009)
Ind. diversity$_{i\,(t-1\,\text{to}\,t-3)}$			0.084**	(0.029)			0.093***	(0.017)	0.113***	(0.020)
Ind. diversity$_{i\,(t-1\,\text{to}\,t-3)\text{squared}}$			−0.013**	(0.005)			−0.024**	(0.009)	−0.031***	(0.011)
Absorptive capacity$_{i\,(t-1\,\text{to}\,t-3)}$			0.390***	(0.083)	0.404***	(0.082)	0.417***	(0.081)	0.392***	(0.085)
Moderating variables										
Absorptive capacity$_{i\,(t-1\,\text{to}\,t-3)}$ × ln (CVC amt.)$_{i\,(t-1\,\text{to}\,t-3)}$					−0.072*	(0.035)			−0.120	(0.073)
Absorptive capacity$_{i\,(t-1\,\text{to}\,t-3)}$ × ln (CVC amt.)$_{i\,(t-1\,\text{to}\,t-3)\text{squared}}$					0.017	(0.012)			0.011*	(0.005)
Absorptive capacity$_{i\,(t-1\,\text{to}\,t-3)}$ × Ind. diversity$_{i\,(t-1\,\text{to}\,t-3)}$							−0.069**	(0.024)	−0.152**	(0.053)
Absorptive capacity$_{i\,(t-1\,\text{to}\,t-3)}$ × Ind. diversity$_{i\,(t-1\,\text{to}\,t-3)\text{squared}}$							0.025**	(0.009)	0.035**	(0.012)
Control variables										
M&A experience$_{i\,(t-1\,\text{to}\,t-3)}$	0.007	(0.004)	0.002	(0.004)	0.001	(0.004)	0.003	(0.004)	−0.001	(0.004)
Alliance experience$_{i\,(t-1\,\text{to}\,t-3)}$	0.006***	(0.001)	0.008***	(0.001)	0.008***	(0.001)	0.007***	(0.001)	0.008***	(0.001)
ln (patent stock)$_{i\,(t-1\,\text{to}\,t-5)}$	0.367***	(0.013)	0.354***	(0.012)	0.352***	(0.011)	0.352***	(0.011)	0.351***	(0.011)
ln (sales)$_{i\,(t-1)}$	0.055***	(0.012)	0.050***	(0.011)	0.043***	(0.012)	0.044***	(0.011)	0.039***	(0.011)
Quality of portfolio companies$_{i\,(t-1\,\text{to}\,t-3)}$	0.000***	(0.000)	0.000***	(0.000)	0.000***	(0.000)	0.000**	(0.000)	−0.000***	(0.000)
Industry dummies	Yes		Yes		Yes		Yes		Yes	
Constant	1.383***	(0.061)	1.109***	(0.077)	1.101***	(0.077)	1.095***	(0.076)	1.118***	(0.078)
Log-likelihood	−4409.60		−4366.23		−4268.95		−4279.49		−4161.84	
Log-likelihood ratio χ^2	260.24		319.77		331.22		322.74		350.93	

Note: $n = 1313$; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

it applies for patents will gradually increase to some degree, but as the company invests more and more of its scarce resources, the diversity will start to decrease. In Model 2, the linear term of *Total Amount of CVC Investments* is positive and statistically significant ($p < 0.001$) and the squared term is negative and significant ($p < 0.001$). Therefore the empirical results support our Hypothesis 1.

Hypothesis 2 predicts a curvilinear relationship between the portfolio diversity of CVC investment and technological diversity of the investor firm. We argue that as the company diversifies its CVC investments among venture companies in various industry fields, its technological diversity as measured by the patent classes in which it applies for new patents, will steadily increase to some extent, but after a certain point, further diversifying the investment, will lead to a decreased investor firm's technological diversity. In Model 2, the linear term of *Industrial Diversity of Portfolio Companies* is positive and statistically significant ($p < 0.01$) and the squared term is negative and significant ($p < 0.01$). These results support Hypothesis 2.

Model 3 and 4 identify the moderating effects of the previous two independent variables and our moderating variable, *Absorptive Capacity*, while Model 5 is the full model that includes all the variables. To uncover the moderating effect of *Absorptive Capacity*, we created the interaction terms of the independent variables and parameterized them. In Model 3, which tests the moderating effect of *Absorptive Capacity* on the relationship between the *Total Amount of CVC Investments* and *Technological Diversity of CVC Investors*, the interaction of the linear term and *Absorptive Capacity* is negative and statistically significant ($p < 0.05$), whereas the interaction of the squared term and *Absorptive Capacity* is positive and insignificant ($p > 0.05$). While the interaction of the linear term in Model 5 is negative and insignificant ($p > 0.05$), the interaction of the squared term is positive and significant ($p < 0.05$). Moreover, the result of the log-likelihood test show that the fully specified model with interaction terms has an improved model fit. Summarizing the results of Model 3 and 5, Hypothesis 3 which predicts that CVC investor's *Absorptive Capacity* positively moderates the relationship between the *Total Amount of CVC Investment* and the *Investor's Technological Diversity* is partially supported.

Model 4 tests the moderating effect of *Absorptive Capacity* on the relationship between *Industrial Diversity of CVC Investments* and *Technological Diversity of CVC Investors*. In the model, the interaction of the linear term and *Absorptive Capacity* is negative and significant ($p < 0.01$), whereas the interaction of the squared term and *Absorptive Capacity* is positive and significant ($p < 0.01$). Model 5, the full model, also shows the similar results. Based on the results of Model 4 and 5, Hypothesis 4 which states that CVC investor's *Absorptive Capacity* positively moderates the relationship between the quality of CVC investment and the investor's technological diversity is supported.

4.3 Reverse Causality

We also conducted an additional robustness test to deal with possible problems stemming from "reverse causality". One could argue that the corporate investors' technological diversification is not an effect but rather a cause of their CVC investment efforts.

To address this problem, we reversed the temporal order of our independent variable and dependent variable for Hypothesis 1. In other words, we set "Technological Diversity of CVC Investors ($t - 1$ to $t - 3$)" as the lagged independent variable and "Total Amount of

Table 3. Reverse causality test (regression model for total amount of CVC investment in t to $t + 2$)

Variables	Model 6		Model 7	
Independent variables				
Patent diversity$_{i\ (t-1\ \text{to}\ t-3)}$			-0.002	(0.003)
Patent diversity$_{i\ (t-1\ \text{to}\ t-3)\text{squared}}$			-0.000	(0.000)
Control variables				
M&A experience$_{i\ (t-1\ \text{to}\ t-3)}$	0.065***	(0.008)	0.063***	(0.008)
Alliance experience$_{i\ (t-1\ \text{to}\ t-3)}$	-0.009***	(0.003)	-0.009***	(0.003)
ln (patent stock)$_{i\ (t-1\ \text{to}\ t-5)}$	0.220***	(0.040)	0.277***	(0.056)
ln (sales)$_{i\ (t-1)}$	0.141*	(0.057)	0.168**	(0.058)
Quality of portfolio companies$_{i\ (t-1\ \text{to}\ t-3)}$	0.002***	(0.001)	0.002***	(0.001)
Industry dummies	Yes		Yes	
Constant	1.264	(1.276)	0.969	(1.293)
R^2	0.259		0.265	
Wald χ^2	276.81		280.78	

Note: $n = 1313$; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

CVC Investments (t to $t + 2$)" as the lagged dependent variable, and performed our regression analysis. In the results of the reverse-order regression analysis, shown in Table 3, we cannot find any statistically significant relationships between the two lagged variables. This indicates that the possibility of a reverse causality problem between CVC investments and subsequent technological diversifications is neglectable.

5. Discussion and Conclusion

This study investigates the role of CVC investment as a strategy for established firms to create diversified technological options to prepare for future change. Specifically, we examined the effects of CVC investments into technologically capable venture companies on the corporate investors' technological diversity. We analyzed patent and CVC investment data of 97 high-tech firms within the US that have participated in CVC investments between 1990 and 2010. The results of our empirical analysis help to support our hypotheses on the effects of CVC investments on the investor firms' technological diversification.

Our study sheds new light on the relationship between a firm's CVC investment and its technological diversification. More specifically, a curvilinear relationship was found between the amount of CVC investment and the investors' technological diversity. A similar relationship was also found between the industrial diversity of the venture portfolio companies and the resulting technological diversity of the investor firms. While increasing the scale of the CVC investment and diversifying the investment portfolio can lead to an increased technological diversity, beyond a certain point, the positive effects were found to be diminishing and firms need to understand that they may not necessarily be able to increase their technological diversity simply through enlarging the scale and scope of their CVC investment portfolios.

The moderating effect of the firms' absorptive capacity (R&D intensity) could then be utilized as a solution to the limitations posed by CVC investment. Although CVC investments

are a valuable strategy for searching new technologies and business opportunities, firms without the capabilities to absorb the new technologies and recombine them with its existing knowledge base might find that the benefits for them are limited. On the other hand, firms who already perform well in R&D related activities will possess a broad range of capabilities related to the identification and recombination of knowledge. For these firms, an increase in CVC investment will result in the new knowledge being efficiently used in the creation of technological innovation in various fields.

We increased the quality of our results by controlling for other factors that might influence technological diversity such as the use of other external knowledge sourcing modes like strategic alliances and M&A's, as well as the investor firm's total sales, cumulated patent stocks, fixed effects of industries and the quality of portfolio companies.

5.1 Contribution

Overall, this study's contribution can be summarized in 3 points. First, this study offers an empirical perspective in evaluating the strategic value of CVC investments. While previous literature has acknowledged the role of CVC investments as a technological window (Chesbrough 2002; Dushnitsky and Lenox 2005; Schildt, Maula, and Keil 2005; Maula, Keil, and Zahra 2003; Wadhwa and Kotha 2006; Van de Vrande, Vanhaverbeke, and Duysters 2009), studies that have examined the effects of CVC investments on the corporate investor's technological innovation tend to focus on the quantitative increase in the creation of technology using measures such as the number of patents created (Dushnitsky and Lenox 2005; Wadhwa and Kotha 2006). On the other hand, our study further analyzed the distribution of those patents among the different patent classes, allowing us to explore the relationship between CVC investment and the corporate investor's technological diversification.

So far, the influence of external learning on a firm's technological diversification has mainly been investigated in the context of strategic alliances (Leten, Belderbos, and Van Looy 2007; Giuri, Hagedoorn, and Mariani 2004; Mowery, Oxley, and Silverman 1998). Giuri, Hagedoorn, and Mariani (2004) empirically examined the positive relationship between external diversification strategy through diverse strategic alliances and the firms' internal technological profile diversity. However, previous literature in the field of CVC has fallen short of providing sufficient empirical evidence on whether, similar to strategic alliances, also CVC investments can contribute to a firm's technological diversification. This study empirically investigates whether CVC investments contribute to creating diverse technological options and differentiates itself from existing CVC literature which focused on the amount of technology innovation output as a result of CVC investments.

Second, this study focuses on external learning strategy through CVC investments and complements previous literature which suggests theoretical linkages between dynamic capabilities and ambidexterity. To survive in an environment of high technological and market uncertainty, previous literature emphasizes firms' dynamic capabilities which involve sensing, seizing and reconfiguring rather than the static capabilities associated with the paradigm of the resource-based view (Adner and Helfat 2003; Ethiraj et al. 2005; Helfat and Peteraf 2003; Teece, Pisano, and Shuen 1997). O'Reilly and Tushman (2008) connect the concept of dynamic capabilities with the ambidexterity framework and suggest how firms' ambidextrous activities result in developing their dynamic capabilities. Kyläheiko, Sandström, and Virkkunen (2002) adopt a real options approach to dynamic capabilities

and suggest that creating various strategic options increases strategic flexibility and enable firms to rapidly address various environmental changes. In this study, we regard CVC investments on technologically proficient start-up companies as explorative learning of established firms and examine how the CVC investments contribute to securing various technological options and consequently improving their dynamic capabilities. In our study, multiple technological options are measured by analyzing the corporate investors' technological diversity after the CVC investments. This measure allows us to examine whether searching and learning diverse external knowledge sources through CVC investments expand the scope of the firms' technological knowledge pool.

Finally, while not only considering the size of the CVC investment portfolio but also its industrial diversity, we examine the influence of firm capabilities related to the absorption of external knowledge on creating technologically diversified options. This study provides firms managerial insights into how they should deploy their CVC investments. Rather than follow in the footsteps of Google or Intel and simply trying to build up a large and diversified CVC portfolio, managers need to be aware of the reduced returns when increasing the scale and scope of the CVC investment beyond a certain point. In addition, based on the findings of this study, firms should examine their own absorptive capacity and determine a suitable level of diversity of their CVC investment portfolio to obtain the best returns from their CVC investments.

5.2 Limitations & Future Research

While providing important insights into the relationships between CVC investments and corporate investors' technological diversification, our study has several theoretical and analytical limitations. First, some limitations arise from the data used to test our hypotheses. In our data-set, investment portfolio technological diversity is measured by the industrial diversity of portfolio companies. This can cause some problems as companies in the same industry might operate using different technology and vice versa. While we acknowledge that the patent class diversity of the target companies (start-ups) would be a better measure for the diversity of the technological knowledge pool of CVC investments, unfortunately, most start-up companies (more than 50 per cent) in our sample have not applied for patents (yet). Thus we were forced to use the available industry classification data to operationalize technology diversity. Future research could collect more detailed samples including patent records, which would also allow to examine the knowledge flow and technological overlap between the target companies and the corporate investors through patent citation analysis, which might provide new insights into how these factors affect the investors' innovation performance. In addition, as our data-set does not contain firms which did not perform CVC investments, we could not check for different tendencies of technological diversifications between a CVC investors group and a non-CVC control group, which might affect the results. Several analysis methods such as Propensity Score Matching (PSM; Rosenbaum and Rubin 1983) analysis and Rubin Causal Model (Rubin 1974) can be used to compare the strategic tendencies of each group. These analyses require very big data samples due to the need to find firm data that can be matched with the experiment group data. We hope that future research will have access to such a data sample containing information on CVC investors as well as a control group of similar firms to further to further increase the quality of the findings on the effects of CVC investment on the focal firms.

Second, this study also has some limitations in interpreting the strategic objectives of CVC investors. Among the strategic objectives of CVC investments, this study highlights the access to technology and knowledge in various new fields. By accessing such new and diverse technology, incumbent firms (CVC investors) can acquire diversified technology options which allow them to respond to technological paradigm shifts in an uncertain environment. Previous survey carried out by MacMillan et al. (2008), which concluded that 65 per cent of corporate investors have strategic objectives of their investments and 86 per cent of their objectives focus on searching for new technology and business opportunities, also support the significance of our approach. However, corporate investors also try to support their existing business through CVC investments. In Ernst & Young's 'Global corporate venture capital survey 2008−09', more than half of corporate respondents expect that CVC investments would also contribute to their existing business. The survey results imply that incumbent firms expect effects of exploitation as well as exploration through CVC investments. Thus some corporate investors might set up a targeted investment portfolio which contributes to their existing business instead of a diversified one. Even though they are searching for new technological opportunities, they still may focus on a specific field along their preexisting R&D direction. To complement and justify the premise of our research, firms pursuing diversity in their CVC investment portfolios, we recommend future research to include a survey or other means to examine the investors' perspectives on their CVC investments.

Third, capturing the creation of new technology only from patent application data is another limitation of this study. Not every technological innovation is being protected by applying for a patent. Thus the findings of this study do not account for the creation of non-codified and tacit knowledge (Wadhwa and Kotha 2006). Moreover, some companies are not willing to disclose their information through patent applications. Therefore the results of this study might underestimate the effects of CVC investments. We recommend future research to include some other variables relating to new product development to capture non-patented types of knowledge creation.

Finally, this paper did not control for technological capabilities and the quality of human resources of target venture companies due to the lack of data on venture companies' R&D efforts and human capital (e.g. the number of Ph.D. degree holders working for the company). Thus we could not investigate the impact of these characteristics on corporate investors' level of learning from their investment portfolio. We look forward to future research with data on the venture firms' technological capabilities and human resources. This will lead to obtaining more in-depth implications as a result of a better understanding of the influence of portfolio quality on the return of CVC investments.

In conclusion, by investigating the effects on firms' innovative performance from the perspective of technological diversification and new options creation, we hope our study contributes to the research on CVC investment's strategic value. We also hope that our study helps future researchers in further deepening their understanding of the impact of CVC investments on corporate investors.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

References

Adner, R., and C. E. Helfat. 2003. "Corporate Effects and Dynamic Managerial Capabilities." *Strategic Management Journal* 24 (10): 1011−1025. doi:10.1002/smj.331.

Ahuja, G. 2000. "The Duality of Collaboration: Inducements and Opportunities in the Formation of Interfirm Linkages." *Strategic Management Journal* 21 (3): 317−343. doi:10.1002/(SICI)1097-0266(200003)21:3<317:AID-SMJ90>3.0.CO;2-B.

Ahuja, G., and R. Katila. 2001. "Technological Acquisitions and the Innovation Performance of Acquiring Firms: A Longitudinal Study." *Strategic Management Journal* 22 (3): 197−220. doi:10.1002/smj.157.

Anand, N., H. K. Gardner, and T. Morris. 2007. "Knowledge-Based Innovation: Emergence and Embedding of New Practice Areas in Management Consulting Firms." *Academy of Management Journal* 50 (2): 406−428.

Argyres, N. 1996. "Capabilities, Technological Diversification and Divisionalization." *Strategic Management Journal* 17 (5): 395−410. doi:10.1002/(SICI)1097-0266(199605)17:5<395:AID-SMJ826>3.0.CO;2-E.

Arrow, K. 1962. "Economic Welfare and the Allocation of Resources for Innovations." In *The Rate and Direction of Incentive Activity: Economic and Social Factors*, 609−626. Princeton, NJ: Princeton University Press.

Benson, D., and R. H. Ziedonis. 2009. "Corporate Venture Capital as a Window on New Technologies: Implications for the Performance of Corporate Investors When Acquiring Startups." *Organization Science* 20 (2): 329−351. doi:10.1287/orsc.1080.0386.

Breschi, S., F. Lissoni, and F. Malerba. 2003. "Knowledge-Relatedness in Firm Technological Diversification." *Research Policy* 32 (1): 69−87. doi:10.1016/S0048-7333(02)00004-5.

Brown, S. L., and K. M. Eisenhardt. 1997. "The Art of Continuous Change: Linking Complexity Theory and Time-Paced Evolution in Relentlessly Shifting Organizations." *Administrative Science Quarterly* 42 (1): 1−34. doi:10.2307/2393807.

Chesbrough, H. W. 2002. "Making Sense of Corporate Venture Capital." *Harvard Business Review* 32 (3): 4−11.

Cohen, W. M., and D. A. Levinthal. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly* 35 (1): 128−152. doi:10.2307/2393553.

Cui, A. S., and G. O'Connor. 2012. "Alliance Portfolio Resource Diversity and Firm Innovation." *Journal of Marketing* 76 (4): 24−43. doi:10.1509/jm.11.0130.

Duncan, R. B. 1976. "The Ambidextrous Organization: Designing Dual Structures for Innovation." In *The Management of Organization*, edited by R. H. Killman, L. R. Pondy, and D. Sleven. Vol. 1, 167−188. New York: North Holland.

Dushnitsky, G., and D. Lavie. 2010. "How Alliance Formation Shapes Corporate Venture Capital Investment in the Software Industry: A Resource-Based Perspective." *Strategic Entrepreneurship Journal* 4 (1): 22−48. doi:10.1002/sej.81.

Dushnitsky, G., and M. J. Lenox. 2005. "When Do Incumbents Learn from Entrepreneurial Ventures? Corporate Venture Capital and Investing Firm Innovation Rates." *Research Policy* 34 (5): 615−639.

Duysters, G., K. H. Heimeriks, B. Lokshin, E. Meijer, and A. Sabidussi. 2012. "Do Firms Learn to Manage Alliance Portfolio Diversity? The Diversity−Performance Relationship and the Moderating Effects of Experience and Capability." *European Management Review* 9 (3): 139−152.

Eisenhardt, K. M., and J. A. Martin. 2000. "Dynamic Capabilities: What Are They?" *Strategic Management Journal* 21 (10−11): 1105−1121. doi:10.1002/1097-0266(200010/11)21:10/11<1105:AID-SMJ133>3.0.CO;2-E.

Engel, D. 2004. "The Performance of Venture-Backed Firms: The Effect of Venture Capital Company Characteristics." *Industry & Innovation* 11 (3): 249−263. doi:10.1080/1366271042000265401.

Ethiraj, S. K., P. Kale, M. S. Krishnan, and J. V. Singh. 2005. "Where Do Capabilities Come from and How Do They Matter? A Study in the Software Services Industry." *Strategic Management Journal* 26 (1): 25−45. doi:10.1002/smj.433.

Evans, J. L., and S. H. Archer. 1968. "Diversification and the Reduction of Dispersion: An Empirical Analysis." *Journal of Finance* 23 (5): 761−767.

Fernhaber, S. A., and P. C. Patel. 2012. "How Do Young Firms Manage Product Portfolio Complexity? The Role of Absorptive Capacity and Ambidexterity." *Strategic Management Journal* 33 (13): 1516−1539.

Giuri, P., J. Hagedoorn, and M. Mariani. 2004. "Technological Diversification and Strategic Alliances." In *The Economics and Management of Technological Diversification*, edited by J. Cantwell, A. Gambardella, and O. Granstrand, Chapter 5. London, UK: Routledge.

Gompers, P. A., and J. Lerner. 2000. "The Determinants of Corporate Venture Capital Successes: Organizational Structure, Incentives, and Complementarities." In *Concentrated Corporate Ownership*, edited by R. Morck, 17−50. Chicago, IL: University of Chicago Press.

Grant, R. M. 1996. "Toward a Knowledge-Based Theory of the Firm." *Strategic Management Journal* 17 (S2): 109−122. doi:10.1002/smj. 4250171110.

Hagedoorn, J., and J. Schakenraad. 1994. "The Effect of Strategic Technology Alliances on Company Performance." *Strategic Management Journal* 15 (4): 291−309. doi:10.1002/smj.4250150404.

Hausman, J. A., B. H. Hall, and Z. Griliches. 1984. "Econometric Models for Count Data with an Application to the Patents-R&D Relationship." *Econometrica* 52 (4): 909−938. doi:10.2307/1911191.

Helfat, C. E., and M. A. Peteraf. 2003. "The Dynamic Resource-Based View: Capability Lifecycles." *Strategic Management Journal* 24 (10): 997−1010. doi:10.1002/smj.332.

Henderson, R. 1993. "Underinvestment and Incompetence as Responses to Radical Innovation: Evidence from the Photolithographic Alignment Equipment Industry." *The RAND Journal of Economics* 24 (2): 248−271. doi:10.2307/2555761.

Henderson, R., and I. Cockburn. 1996. "Scale, Scope, and Spillovers: The Determinants of Research Productivity in Drug Discovery." *The RAND Journal of Economics* 27 (1): 32−59. doi:10.2307/2555791.

Huang, Y. F., and C. J. Chen. 2010. "The Impact of Technological Diversity and Organizational Slack on Innovation." *Technovation* 30 ((7−8)): 420−428.

Janney, J. J., and G. G. Dess. 2004. "Can Real-Options Analysis Improve Decision-Making? Promises and Pitfalls." *Academy of Management Perspectives* 18 (4): 60−75.

Jensen, M. C. 1969. "Risk, the Pricing of Capital Assets, and the Evaluation of Investment Portfolios." *The Journal of Business* 42 (2): 167−247. doi:10.1086/295182.

Keil, T. 2002. *External Corporate Venturing: Strategic Renewal in Rapidly Changing Industries*. Westport, CT: Quorum Books, Praeger.

Keil, T. 2004. "Building External Corporate Venturing Capability." *Journal of Management Studies* 41 (5): 799−825. doi:10.1111/j.1467-6486.2004.00454.x.

Kogut, B. 1991. "Joint Ventures and the Option to Expand and Acquire." *Management Science* 37 (1): 19−33. doi:10.1287/mnsc.37.1.19.

Kogut, B., and U. Zander. 1992. "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology." *Organization Science* 3 (3): 383−397. doi:10.1287/orsc.3.3.383.

Kotrum, S., and J. Lerner. 2000. "Assessing the Contribution of Venture Capital to Innovation?" *The RAND Journal of Economics* 31 (4): 674−692.

Kyläheiko, K., J. Sandström, and V. Virkkunen. 2002. "Dynamic Capability View in Terms of Real Options." *International Journal of Production Economics* 80 (1): 65−83.

Leten, B., R. Belderbos, and B. Van Looy. 2007. "Technological Diversification, Coherence, and Performance of Firms." *Journal of Product Innovation Management* 24 (6): 567−579. doi:10.1111/j.1540-5885.2007.00272.x.

Levinthal, D. A., and J. G. March. 1993. "The Myopia of Learning." *Strategic Management Journal* 14 (S2): 95−112. doi:10.1002/smj. 4250141009.

Lin, B. W., C. J. Chen, and H. L. Wu. 2006. "Patent Portfolio Diversity, Technology Strategy, and Firm Value." *IEEE Transactions on Engineering Management* 53 (1): 17−26.

Lin, C., Y. Wu, C. Chang, W. Wang, and C. Lee. 2012. "The Alliance Innovation Performance of R&D Alliances—The Absorptive Capacity Perspective." *Technovation* 32 (5): 282−292. doi:10.1016/j.technovation.2012.01.004.

March, J. G. 1991. "Exploration and Exploitation in Organizational Learning." *Organization Science* 2 (1): 71−87. doi:10.1287/orsc.2.1.71.

Markowitz, H. 1952. "Portfolio Selection." *Journal of Finance* 7 (1): 77−91.

Maula, M. V. J. 2001. "Corporate Venture Capital and the Value-Added for Technology-Based New Firms." Doctoral dissertation, Helsinki University of Technology, Institute of Strategy and International Business.

Maula, M. V. J., T. Keil, and S. A. Zahra. 2003. "Corporate Venture Capital and Recognition of Technological Discontinuities." . Academy of management annual meeting, Seattle.

Maula, M. V. J., T. Keil, and S. A. Zahra. 2013. "Top Management's Attention to Discontinuous Technological Change: Corporate Venture Capital as an Alert Mechanism." *Organization Science* 24 (3): 926–947. doi:10.1287/orsc.1120.0775.

Mitchell, W., and K. Singh. 1992. "Incumbents' Use of Pre-Entry Alliances Before Expansion into New Technical Subfields of an Industry." *Journal of Economic Behavior & Organization* 18 (3): 347–372. doi:10.1016/0167-2681(92)90015-4.

Mowery, D. C., J. E. Oxley, and B. S. Silverman. 1998. "Technological Overlap and Interfirm Cooperation: Implications for the Resource-Based View of the Firm." *Research Policy* 27 (5): 507–523. doi:10.1016/S0048-7333(98)00066-3.

Nelson, R., and S. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap.

Norton, E., and B. H. Tenenbaum. 1993. "Specialization Versus Diversification as a Venture Capital Investment Strategy." *Journal of Business Venturing* 8 (5): 431–442. doi:10.1016/0883-9026(93)90023-X.

Oerlemans, L. A. G., J. Knoben, and M. W. Pretorius. 2013. "Alliance Portfolio Diversity, Radical and Incremental Innovation: The Moderating Role of Technology Management." *Technovation* 33 ((6–7)): 234–246.

O'Reilly, C. A., and M. L. Tushman. 2008. "Ambidexterity as a Dynamic Capability: Resolving the Innovator's Dilemma." *Research in Organizational Behavior* 28: 185–206. doi:10.1016/j.riob.2008.06.002.

Patel, P., and K. Pavitt. 1997. "The Technological Competencies of the World's Largest Firms: Complex and Path-Dependent, but Not Much Variety." *Research Policy* 26 (2): 141–156. doi:10.1016/S0048-7333(97)00005-X.

Pavitt, K. 1998. "Technologies, Products and Organization in the Innovating Firm: What Adam Smith Tells Us and Joseph Schumpeter Doesn't." *Industrial and Corporate Change* 7 (3): 433–452. doi:10.1093/icc/7.3.433.

Percival, J. C., and B. P. Cozzarin. 2008. "Complementarities Affecting the Returns to Innovation." *Industry & Innovation* 15 (4): 371–392. doi:10.1080/13662710802273249.

Phelps, C. C. 2010. "A Longitudinal Study of the Influence of Alliance Network Structure and Composition on Firm Exploratory Innovation." *Academy of Management Journal* 53 (4): 890–913. doi:10.5465/AMJ.2010.52814627.

Raisch, S., J. Birkinshaw, G. Probst, and M. L. Tushman. 2009. "Organizational Ambidexterity: Balancing Exploitation and Exploration for Sustained Performance." *Organization Science* 20 (4): 685–695. doi:10.1287/orsc.1090.0428.

Rosenbaum, P. R., and D. B. Rubin. 1983. "The Central Role of the Propensity Score in Observational Studies for Causal Effects." *Biometrika* 70 (1): 41–55. doi:10.1093/biomet/70.1.41.

Rosenkopf, L., and A. Nerkar. 2001. "Beyond Local Search: Boundary-Spanning, Exploration, and Impact in the Optical Disk Industry." *Strategic Management Journal* 22 (4): 287–306. doi:10.1002/smj.160.

Rothaermel, F. T., and M. T. Alexandre. 2009. "Ambidexterity in Technology Sourcing: The Moderating Role of Absorptive Capacity." *Organization Science* 20 (4): 759–780. doi:10.1287/orsc.1080.0404.

Rubin, D. B. 1974. "Estimating Causal Effects of Treatments in Randomized and Nonrandomized Studies." *Journal of Educational Psychology* 66 (5): 688–701. doi:10.1037/h0037350.

Sampson, R. C. 2007. "R&D Alliances and Firm Performance: The Impact of Technological Diversity and Alliance Organization on Innovation." *Academy of Management Journal* 50 (2): 364–386. doi:10.5465/AMJ.2007.24634443.

Sanchez, R. 1993. "Strategic Flexibility, Firm Organizations, and Managerial Work in Dynamic Markets: A Strategic Options Perspective." *Advances in Strategic Management* 9: 251–291.

Schildt, H., M. V. J. Maula, and T. Keil. 2005. "Explorative and Exploitative Learning from External Corporate Ventures." *Entrepreneurship Theory and Practice* 29 (4): 493–515. doi:10.1111/j.1540-6520.2005.00095.x.

Schumpeter, J. 1942. *Capitalism, Socialism and Democracy*. New York, NY: Harper & Row.

Shane, S. 2001. "Technology Regimes and New Firm Formation." *Management Science* 47 (9): 1173–1190. doi:10.1287/mnsc.47.9.1173.9785.

Teece, D. J. 2007. "Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance." *Strategic Management Journal* 28 (13): 1319–1350. doi:10.1002/smj.640.

Teece, D. J., G. Pisano, and A. Shuen. 1997. "Dynamic Capabilities and Strategic Management." *Strategic Management Journal* 18 (7): 509–533. doi:10.1002/(SICI)1097-0266(199708)18:7<509:AID-SMJ882>3.0.CO;2-Z.

Torrisi, S., and O. Granstrand. 2004. "Technological and Business Diversification: A Survey of Theories and Empirical Evidence." In *The Economics and Management of Technological Diversification*, edited by J. Cantwell, A. Gambardella, and P. Granstrand, Chapter 2. London, UK: Routledge.

Tushman, M. L., and C. A. O'Reilly. 1996. "The Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change." *California Management Review* 38 (4): 8–30. doi:10.2307/41165852.

Tushman, M. L., and P. Anderson. 1986. "Technological Discontinuities and Organizational Environments." *Administrative Science Quarterly* 31 (3): 439–465. doi:10.2307/2392832.

Van de Vrande, V. 2013. "Balancing Your Technology-Sourcing Portfolio: How Sourcing Mode Diversity Enhances Innovative Performance." *Strategic Management Journal* 34 (5): 610–621. doi:10.1002/smj.2031.

Van de Vrande, V., and W. Vanhaverbeke. 2013. "How Prior Corporate Venture Capital Investments Shape Technological Alliances: A Real Options Approach." *Entrepreneurship Theory and Practice* 37 (5): 1019–1043. doi:10.1111/j.1540-6520.2012.00526.x.

Van de Vrande, V., W. Vanhaverbeke, and G. Duysters. 2009. "External Technology Sourcing: The Effect of Uncertainty on Governance Mode Choice." *Journal of Business Venturing* 24 (1): 62–80. doi:10.1016/j.jbusvent.2007.10.001.

Vanhaverbeke, W., G. Duysters, and N. Noorderhaven. 2002. "External Technology Sourcing Through Alliances or Acquisitions: An Analysis of the Application-Specific Integrated Circuits Industry." *Organization Science* 13 (6): 714–733. doi:10.1287/orsc.13.6.714.496.

Vassolo, R. S., J. Anand, and T. B. Folta. 2004. "Non-Additivity in Portfolios of Exploration Activities: A Real Options-Based Analysis of Equity Alliances in Biotechnology." *Strategic Management Journal* 25 (11): 1045–1061. doi:10.1002/smj.414.

Wadhwa, A., and S. Kotha. 2006. "Knowledge Creation Through External Venturing: Evidence from the Telecommunications Equipment Manufacturing Industry." *Academy of Management Journal* 49 (4): 819–835. doi:10.5465/AMJ.2006.22083132.

Wadhwa, A, and C. Phelps. 2011. *Take a Chance on Me: An Examination of the Interdependence of Start-Up Tie Formation Across Venture Capital Alliance Networks*. Working Paper.

Yang, Y., V. K. Narayanan, and D. M. De Carolis. 2014. "The Relationship Between Portfolio Diversification and Firm Value: The Evidence from Corporate Venture Capital Activity." *Strategic Management Journal* 35 (13): 1993–2011. doi:10.1002/smj.2190.

Zahra, S. A. 1996. "Technology Strategy and Financial Performance: Examining the Moderating Role of the Firm's Competitive Environment." *Journal of Business Venturing* 11 (3): 189–219.

Zahra, S. A., and J. G. Covin. 1995. "Contextual Influences on the Corporate Entrepreneurship-Performance Relationship: A Longitudinal Analysis." *Journal of Business Venturing* 10 (1): 43–58. doi:10.1016/0883-9026(94)00004-E.

Zahra, S. A., and G. George. 2002. "Absorptive Capacity: A Review, Reconceptualization, and Extension." *Academy of Management Review* 27 (2): 185–203.

Zingales, L. 2000. "In Search of New Foundations." *The Journal of Finance* 55 (4): 1623–1653. doi:10.1111/0022-1082.00262.