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**Ph. D. Dissertation in Engineering**

# External Knowledge Sourcing Strategies through Corporate Venture Capital Investment

## : Focusing on Investor's Innovation Performance, Organizational Structure, and Portfolio Composition

기업벤처캐피털 투자를 통한 외부지식습득 전략: 투자기업의 혁신성과와 조직구조, 투자 포트폴리오 구성을 중심으로

**February 2018**


**Graduate School of Seoul National University**

**Technology Management, Economics, and Policy Program**

**Simon U. Lee (이 상 욱)**

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이 논문을 공학박사학위 논문으로 제출함

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# Abstract

# External Knowledge Sourcing Strategies through Corporate Venture Capital Investment

## : Focusing on Investor's Innovation Performance, Organizational Structure, and Portfolio Composition

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In a modern industrial environment, technological paradigm shifts rapidly and uncertainty is high. Firms face extreme difficulties on predicting which technology can achieve sustainable competitive advantage over other competing firms. In particular, incumbent firms that have already accumulated a significant amount of knowledge and resources in specific technology areas face more difficulties creating new knowledge to help prepare for future changes. In order to overcome these obstacles, it is essential for incumbent firms to combine internal R&D strategies and external sourcing strategies that utilize their existing knowledge while acquiring innovation capabilities outside the

organization.

Recently, corporate venture capital (CVC) has emerged as an important strategic method to find new knowledge and business opportunities from venture companies with high technological potential. CVC investment enables corporate investors to explore information on unfamiliar new business areas or technologies that can be leveraged on current businesses. Further, after the CVC investment, corporate investors can acquire investment target companies' knowledge directly through other sourcing strategies such as strategic alliances or M&A. In fact, in the IT or bio industry where venture companies lead the cutting edge of technological innovation, many incumbent firms are already looking for new innovation opportunities through CVC investment . This trend is continuing in the traditional manufacturing sectors too.

In the academic world, active research is being conducted on the role and value of CVC as a technology innovation strategy. Many empirical studies have shown that corporate investors enjoy positive effects such as improvement of innovation performance or actual corporate value, there are a number of studies on investment portfolio management to obtain more efficient investment performance. However, most of the previous studies have put large emphasis only on the quantitative aspects of firm value or innovation, while not focusing on specific details such as diversity of knowledge or types of innovation that can be acquired through CVC investments. The diversity of knowledge is an essential quality for an incumbent firm in responding to future environmental changes. Moreover, since the types of innovation that results from the CVC investment reflect the strategic objective of

corporate investor, more in-depth discussion is essential and necessary in order to achieve a comprehensive understanding of CVC investments. Considering the interests in the academic research and the practical significance of CVC innovation processes, this dissertation deals with three individual studies on CVC investments, namely, 'technological diversification through CVC investments', 'organizational determinants of CVC portfolio diversification', and 'exploration and exploitation through CVC investments'. Each study covers different aspects of CVC investment activities as a method of organizational learning or external knowledge sourcing strategy. Synthetically, this dissertation explores the nature of the firm's innovation strategy through CVC investment and analyzes the effects of specific organizational structures and decision-making processes on the efficiency of investments.

Specifically, Chapter 3 of this dissertation examines the effect of CVC investments on the technological diversification of investment firms as an 'option creation strategy' for expanding 'dynamic capabilities' of the firms. Previous research and related surveys that discuss the strategic purpose of CVC investments have commonly dealt with the effect of expanding the knowledge base of the investment firms by exploring new knowledge in target venture firms. In other words, the incumbent firm uses CVC investments to increase the diversity of knowledge and technological options that can be utilized in the future by acquiring new knowledge which is different from the investors existing knowledge. However, despite this importance, there have been few studies that have conducted empirical analysis on the effects of knowledge diversification. In order to fill this research

gap, this chapter conducts an empirical analysis of how the amount of resources invested in CVC and the industrial diversity of the investment portfolio affect to the technology diversification of the corporate investor. As a result, the empirical analysis has shown that the total amount of CVC investments and the industrial diversity of portfolio firm have curvilinear (inverted U-shaped) relationship with their technology diversification which is based on the high-tech firms in the U.S. which have experience in CVC investments between 1990 and 2010. Moreover, the empirical results indicate that the absorptive capacity of corporate investors positively moderates the effects of CVC investments on the technological diversity. This result shows that CVC investments have an effect of increasing corporate investor's technological diversification. However, limitations still exist, therefore, the investment firms should not neglect efforts on pursuing internal R&D activities to increase their absorptive capacity.

Chapter 4 executes more in-depth analysis on the details of CVC investment portfolio diversification strategy. As previously mentioned, in order for incumbent firms to access various external knowledge pools through CVC investments, a diversified investment portfolio consisting of venture firms engaged in various technological and industrial areas should be constructed. However, in reality, many CVC investors do not operate diversified portfolio, but rather focuses their investments in small and specific technology areas. This chapter suggests that the differences in the degree of investment portfolio diversification among CVC investors are caused by the different 'managerial attention' of corporate investors which can affect their strategic decision-making when selecting investments

targets. Specifically, this research conducts an empirical analysis on the roles of three antecedent factors that can affect corporate investor's managerial attention regarding the investment target selection such as 'top management team (TMT) members' background homogeneity', 'lack of organizational slack resources', and 'structural autonomy given to the managers of CVC dedicated units'. As a result of analysis, this research has shown that the corporate investors which have homogeneous TMT members and organizational slack resource constraints tend to operate more specialized CVC portfolios rather than diversified portfolios. On the contrary, the corporate investors which assign more decision-making authority to the managerial level of CVC dedicated units were commonly operate more diversified CVC portfolios in various technology areas. These results suggest a managerial implication that if a CVC investment firm wants to access a diverse knowledge pool, it is important to ensure the structural autonomy of CVC dedicated units to be unrestricted from the interference of TMT members' strategically homogenized interests and organizational resource constraints.

However, this structural autonomy of CVC dedicated unit has the potential to play a different role at times, depending on the type of innovation that corporate investors seek to achieve through CVC investments. It is possible that having a free and adventurous investment propensity with more structural autonomy may not always lead to appropriate innovation performance in desired direction. Among the CVC investment firms, some of them are primarily focused on exploring new business opportunities and unfamiliar knowledge that can be used in the future, while others have primary purpose in acquiring

high quality knowledge in familiar technology areas to strengthen their current business areas. Therefore, Chapter 5 of this dissertation examines how the structural autonomy given to the CVC dedicated units affects the two different aspects of innovation; ‘exploration’ and ‘exploitation’. Moreover, in the resource perspective, the effect of investor firm’s internal technological diversity on two kinds of innovation performance. As a result of empirical analysis, it can be found that the CVC dedicated units, which have been granted more structural autonomy, have gained positive impact in explorative innovation activities through free investment target selection in various technology areas. On the other hand, this structural autonomy paradoxically implies a break from the long-term accumulated knowledge and the professional human resources of CVC parent firm. Therefore, it has negative relationship with exploitative innovation which necessarily needs the combination of newly acquired knowledge and existing knowledge base. In addition, I also find that the corporate investor’s internal technological diversity is positively related with both of subsequent exploration and exploitation performance through CVC investments. These results indicate that the corporate investors will be able to obtain the innovation output in the desired direction by deciding the kind of innovation they want and how to operate the CVC units and how to managing the internal knowledge base.

In conclusion, this dissertation deals with the role of CVC investments on accessing external knowledge sources and seizing new business opportunities. It specifically contributes to the academic literatures about the strategic values and organizational characteristics of CVC investments as method of technology diversification. Moreover, it

suggests useful managerial implications for more efficient operation of CVC investment organization. The main results and implications of this research are as follows. First, this research identifies the effects of CVC investments on the technological diversification of corporate investors and puts emphasis on the importance of absorptive capacity as a recommended way to improve those effects. Secondly, this research shows that CVC dedicated units need to operate structurally autonomous, specifically, distant from parent firm's interferences such as TMT members' strategic interests and organizational resources constraints in order to establish a diversified investment portfolio and to access more diverse pools of external knowledge. Finally, this research identifies the structural autonomy of CVC dedicated units as a helpful entity to explorative innovation for long-term change; however, it is negatively related with the exploitative innovation form short-term gains. This suggests that the operation of the CVC department should be changed according to the strategic objectives of the corporate investor.

**Keywords: Corporate venture capital (CVC); external knowledge sourcing strategy; technology diversification; investment portfolio; structural autonomy; exploration and exploitation**

**Student Number: 2010-23364**

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# Chapter 1. Introduction

## 1.1 Backgrounds

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 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). Incumbent firms which have abundant dynamic capabilities can 'sense' new business opportunities from outside of their organizations, 'seize' valuable knowledge appropriate to their business objectives, and 'transform' the acquired knowledge into a form that they can easily use to gain a competitive advantage.

However, since technological and market uncertainty are very high, 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). It is very difficult to possess dynamic capabilities only with incumbent firm's own efforts for innovation such as internal R&D activities. In these

reasons, many scholars argue that in order to possess such dynamic capabilities, it is necessary to combine external knowledge sourcing strategies such as strategic mergers, strategic alliances, and joint ventures with other companies that have useful knowledge as well as internal R&D (Schildt, Maula, and Keil, 2005; Van de Vrande and Vanhaverbeke, 2013).

Recently, corporate venture capital (CVC) investment has been recognized as a very useful strategy for incumbent firms to have dynamic capabilities (Dushnitsky and Lenox, 2005, Lee and Kang, 2015). CVC investment refers to incumbent firms making small equity investments in start-ups with good technological potential (Gompers and Lerner, 2000). CVC investment conducted by a non-financial firm is different from a general venture capital (independent venture capital, IVC) investment. Not only does CVC investment conducted by a non-financial have a goal for financial gain but it also has some strategic purposes such as finding new business opportunities or acquiring valuable knowledge from investment target companies (Benson and Ziedonis, 2009; Block and MacMillan, 1993). Especially in the high-tech industry, small-scale venture start-ups are becoming an important element of innovation because of their quick and flexible decision making process. Therefore, incumbent firms can create creative and strategic options that can be used in the future by accessing the creative ideas and technologies of these venture start-ups through CVC investment. In addition, it is possible to commercialize a good idea of a venture start-ups by utilizing the accumulated resources and know-how of existing companies.

In fact, in technologically advanced countries such as the United States, CVC deals between venture start-ups and incumbent conglomerates are occurring frequently. Incumbent firms across the globe, including global IT companies like Google, Intel and Qualcomm, as well as bio-medicine companies like Pfizer, Biogen, and daily necessities like Johnson & Johnson, are running the CVC fund. According to the CB Insight's survey research, most of target companies of CVC investments are engaged in high-tech industries such as internet, healthcare, mobile & telecom, software (non-internet / mobile) and computer & hardware. Figure 1-1 shows the share of the industrial sector in which CVC investments have been concentrated over the past year.

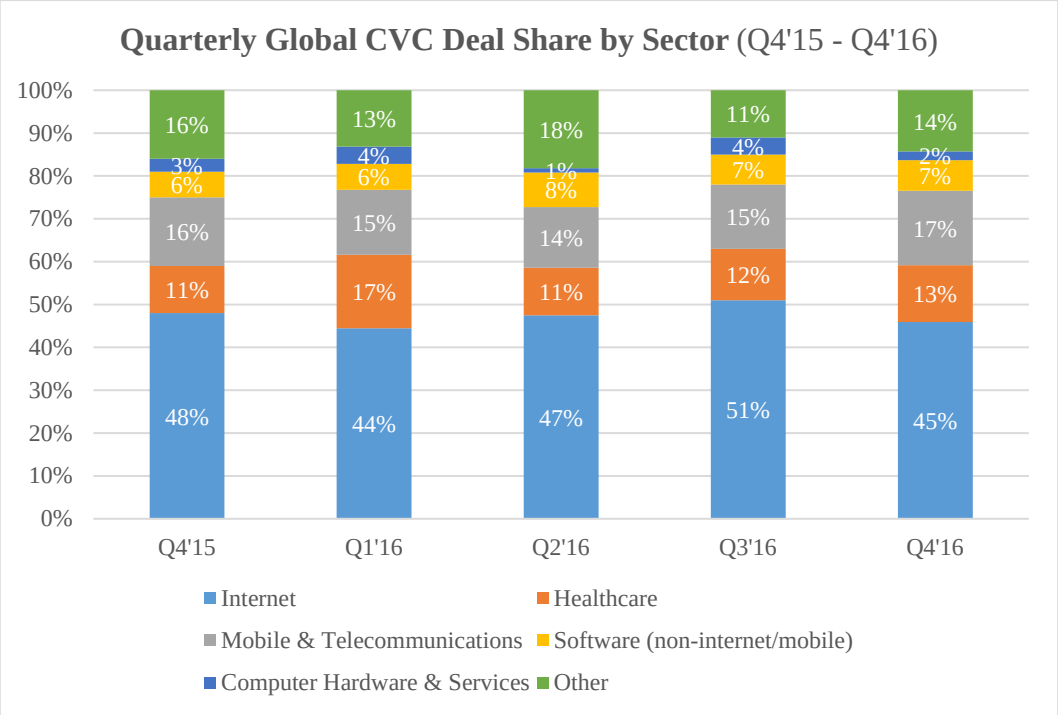


**Figure 1-1.** Quarterly global CVC deal share by sector (Q4'15 – Q4'16)
(Source: CB Insights – 2016 Global Corporate Venture Capital Report)

The number of firms participating in CVC investments is increasing each year since the 2008 global financial crisis. As figure 1-2, the number of global active CVC investors increased from 84 in the first quarter of 2012 to 193 in the fourth quarter of 2016. In particular, 107 new CVC funds, including JetBlue Technology Ventures and Sony Innovation Fund, were first invested in 2016. This growth has been around 20% annually since 2011. In terms of the investment amount, average size of investment in CVC fund is larger than the average size of overall VC funds (Figure 1-3). This means that corporate investors are becoming an important source of funding for investment target companies.

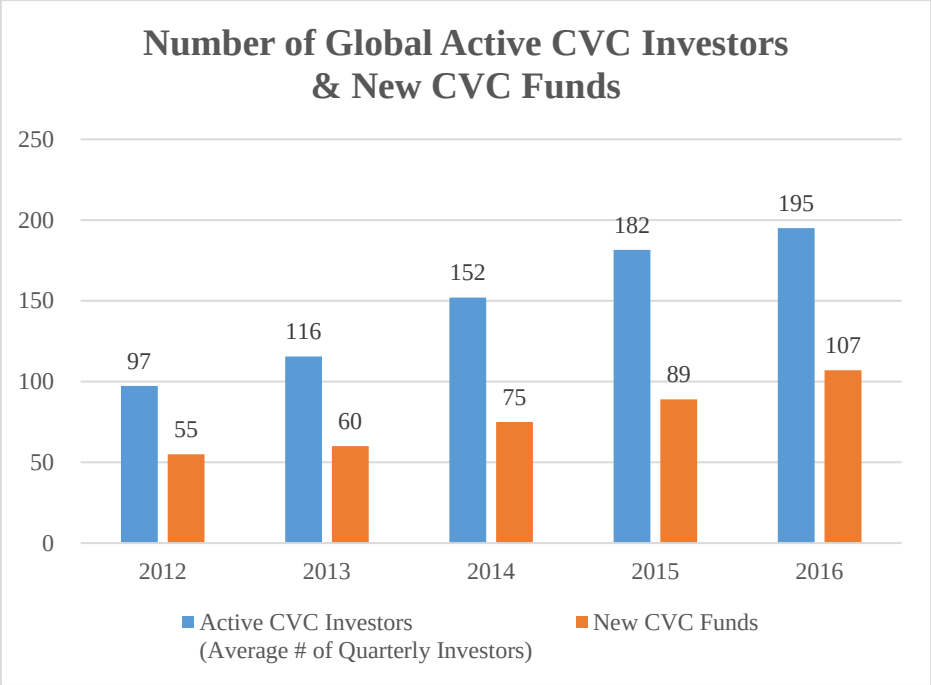


**Figure 1-2.** Number of global active CVC investors & New CVC Funds (Source: CB Insights – 2016 Global Corporate Venture Capital Report)

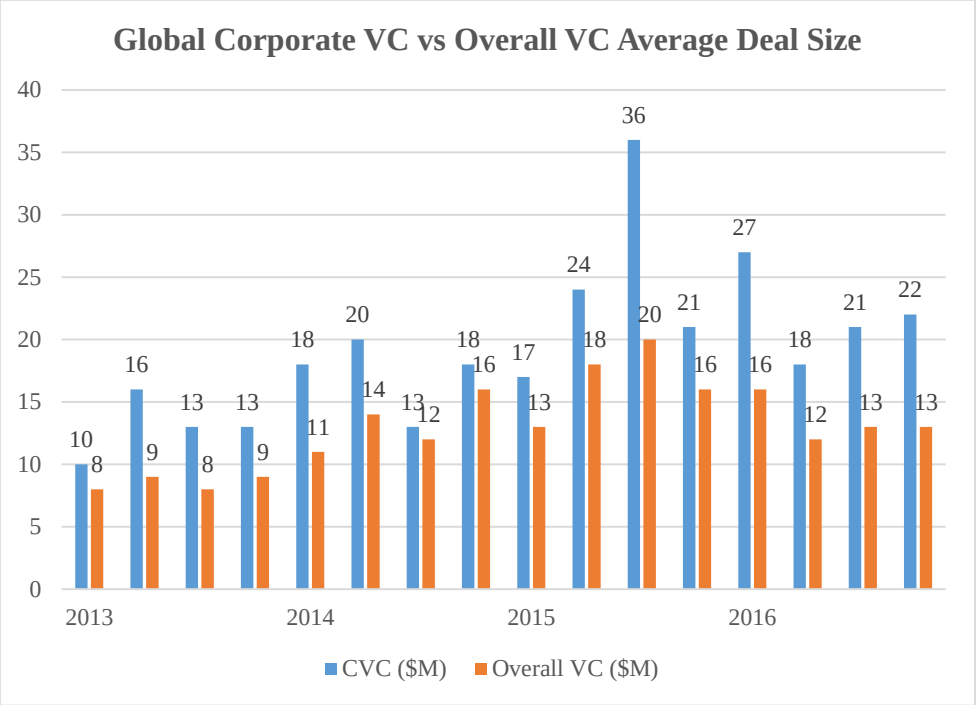


**Figure 1-3.** Global CVC vs Overall VC average deal size
(Source: CB Insights – 2016 Global Corporate Venture Capital Report)

As interest in incumbent firms' CVC investments grows, it is increasingly important to look at CVC investments in their analysis of innovation activities. According to a 2008 survey conducted by the National Institute of Standards and Technology (NIST)[1] in the United States, about 65 percent of CVC investment firms responding to the survey indicated that strategic value is more important than financial return. Therefore, it is necessary to empirically analyze whether this CVC investment actually brings strategic benefits to corporate investors. In addition, if the empirical analysis based on the logical

[1] MacMillan, I., Roberts E., Livada V., and Wang A. (2008) Corporate Venture Capital (CVC): Seeking Innovation and Strategic Growth. *Supported by National Institute of Science and Technology (NIST)*

hypothesis setting can derive the appropriate ways of CVC operations which are suited to the strategic purpose of corporate investors, it will be possible to provide valuable managerial implication to the practitioners.

## 1.2 Research purpose

This dissertation is mainly focused on incumbent firm's innovation strategy through CVC investments. CVC investments are an important strategic method for organizational learning about novel technologies and new business opportunities from entrepreneurial venture start-ups. To actively cope with the rapidly changing market environment, many incumbent firms focus on the creative ideas and cutting-edge technologies of venture start-ups in emerging technology sectors. CVC investment is a useful learning method that provides easy access to this knowledge pool of venture start-ups with high technological potential.

Academic researchers of strategic management are also paying attention to the strategic value of CVC investments. Many previous studies examined the relationships between CVC investments and corporate investor's innovation performance, and a number of studies have also demonstrated a significant relationship between them. However most previous studies on the strategic value of CVC investments have only focused on quantitative aspects of innovation performance. However, many surveys of CVCs found that one of the main reasons for incumbent firms to conduct CVC investments was the

formation of various technological options that could be used in the future. In other words, to better understand the strategic benefits of CVC investments, it is necessary to see whether corporate investors succeed in technology diversification through CVC or not. In addition, it is also necessary to discuss how to operate CVC to maximize the effect of technology diversification.

The purpose of this dissertation is to bridge the gap in knowledge of the strategic roles of CVC investments. Integrating approaches found in the extant literatures and tasks relating to CVC investments, this dissertation investigates various aspects of innovation processes through CVC investments. Three empirical studies analyze CVC's technological diversification effects, impact of organizational antecedents on CVC portfolio diversification, and the effects of structural autonomy given to CVC operation and investor firm's internal technological diversity on its explorative and exploitative innovation activities. Specifically, each study's focus is as follows: The first study examines the effects of two different aspects of CVC - the amount of resources invested in CVC fund and the diversity of technology domains engaged by portfolio companies - on the creation of diversified technology options. Moreover it investigates the moderating role of corporate investor's absorptive capacity. The second study focuses on the three organizational antecedent factors – CVC parent firm's top management team members' homogeneity, organizational slack resource constraint, and structural autonomy of CVC dedicated unit – that can inhibit or encourage CVC portfolio diversity. Finally, the third study, focusing on the innovation performance, aims at demonstrating how structural autonomy given to CVC

operation and investor firm's internal technological diversity affect two different types of innovation activities such as exploration and exploitation.

In sum, this dissertation increases both the academic understanding of CVC investments as well as provides managerial implications for practitioners who conduct CVC investments. First, this dissertation addresses the gaps in the previous research on the strategic roles of CVC investments with empirical analysis. Second, this dissertation contributes to the development of CVC literatures based on the theories of strategic management and organizational behavior such as resource-based view, upper-echelon theory, and managerial attention perspective. Third, this dissertation suggests appropriate ways to manage CVC investment for incumbent firms that seek to access new technological knowledge and business opportunities.

## 1.3 Research outline

This dissertation consists of three key parts: the literature review, three different empirical studies on the technological diversification through CVC investments, the organizational determinants of CVC portfolio diversification, and the explorative and exploitative learning through CVC investments, as well as overall conclusions.

Chapter 2 provides a literature review. This chapter introduces the extant literature on CVC investments from different fields, including organizational learning strategies and venture capital literatures. I focuses on the roles of CVC investments as a method of firm's

external knowledge sourcing strategy and how to properly operate CVC unit in line with the strategic objectives of the corporate investor.

The three empirical studies are covered in Chapter 3, 4, and 5. Figure 1-5 provides an overview of the three topics of empirical studies which deal with different aspects of CVC investments as an innovation strategy.

Chapter 3 investigates the effects of CVC investments on corporate investor's technological diversification. In high-tech industries, CVC investment in technology-intensive entrepreneurial ventures has attracted increasing attention from incumbent 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. To fill this research gap, this chapter examines 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, I 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. These findings suggests that the amount of resources invested in the CVC and the degree of diversification of the investment portfolio play a role in enhancing the technological diversity of the corporate investors to a certain extent, and this effect is

maximized as the absorptive capacity of the corporate investor is higher. Therefore, it can be seen that the incumbent firms that make CVC investments must make efforts to increase their absorptive capacity like internal R&D activities as well as investments for external knowledge sourcing.

Chapter 4 discusses about some antecedent determinants of CVC portfolio diversification. As shown in Chapter 3, in order for corporate investors to access knowledge in various industries, it is effective to diversify their investment portfolio into various knowledge areas. However, in reality, many of the corporate investors actually operate a specialized portfolio focused on few specific industries rather than diversified portfolios. In this chapter, I argue that the degree of CVC portfolio diversification is different for each corporate investor because of its different managerial attention on investment target selection. Based on the in-depth survey of CVC practitioners and some CVC literatures, I investigate the roles of three organizational determinants (TMT homogeneity, organizational slack constraints, and structural autonomy of the CVC unit) which can affect corporate investor's strategic attention. Using 20 years of panel data from corporate investors in U.S. high-tech industries, I find that the CVC parent firm's TMT homogeneity and slack resource constraints negatively affect the CVC's portfolio diversification. On the other hand, the structural autonomy given to the dedicated CVC unit was found to be positively related with CVC portfolio diversification. Therefore, this chapter suggests that a corporate investor which prefers to manage diversified CVC investment portfolios should independently operate the CVC dedicated unit to make it free from the organizational

obstacles such as parent firm TMT members' homogeneous interests and lack of organizational slack resource.

Including Chapter 3 and 4 of this dissertation, most prior literature which empirically analyzed the role of corporate venture capital (CVC) activities as an innovation strategy has focused solely on its role as an explorative learning method. However, in reality, many corporate investors are also using CVC investment for exploitative learning to strengthen their current business model. In Chapter 5, I focus on the operational and resource-based aspects of CVC investments and discuss how the explorative and exploitative innovation performances of corporate investors are affected by the level of the autonomy granted to their CVC dedicated unit and investor firm's technological diversity. Using 20 years of panel data from 77 corporate investors in U.S. high-tech industries, I find that the structural autonomy of the dedicated CVC unit exhibits a positive relationship with the corporate investor's explorative innovation performance, while it is negatively related with exploitative innovation performance. This result provides a managerial implication that the operating mode of the CVC dedicated unit should be changed according to the kind of innovation that the company intends to achieve through CVC investment. In addition, the diversity of internal technological knowledge base of investor firm is positively related with both of exploration and exploitation.

Concluding this dissertation, Chapter 6 provides a summary of the results of this dissertation and concludes with a discussion of academic contributions, managerial implications, limitations, and directions of future research.

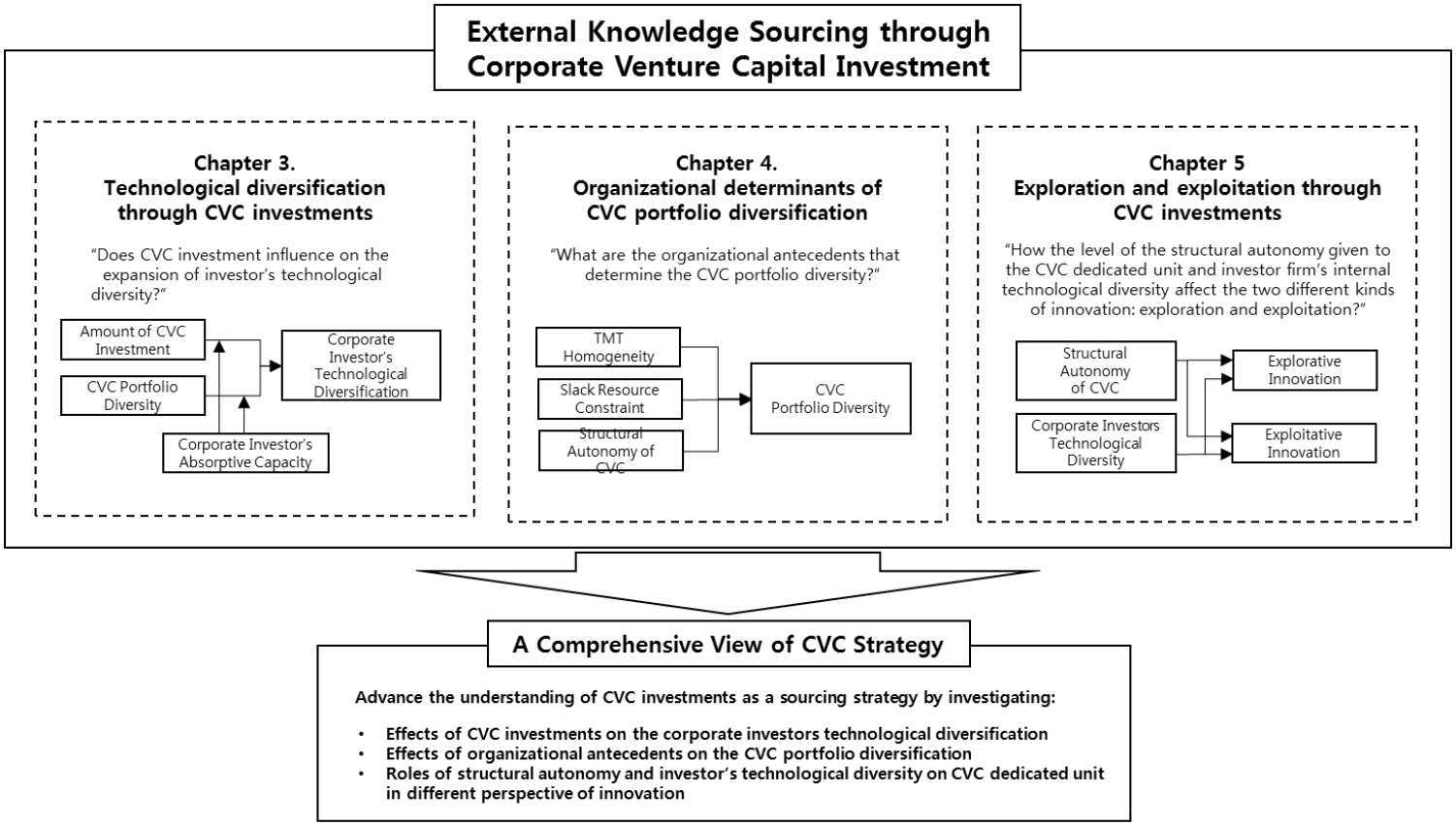


**Figure 1-4.** Conceptual Model for this dissertation

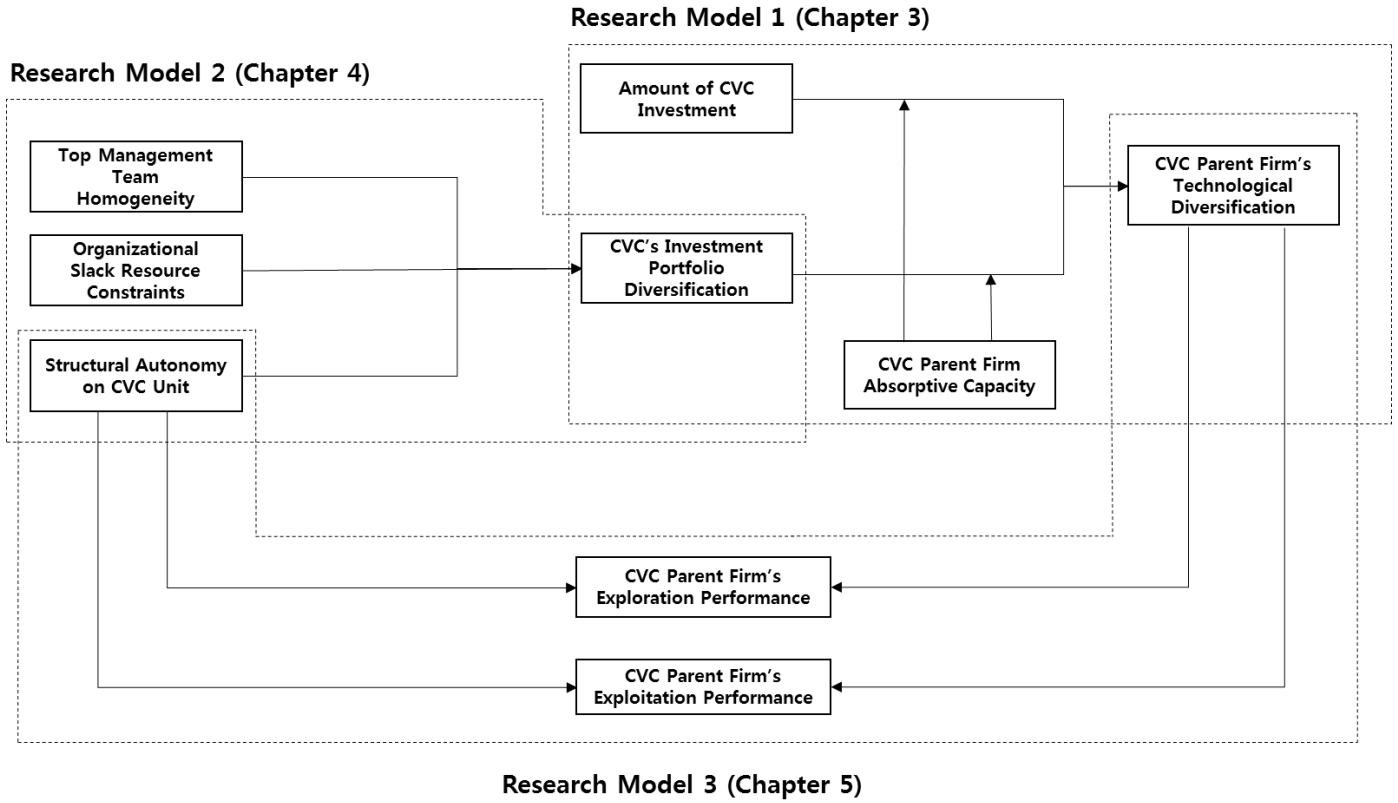


**Figure 1-5.** Comprehensive logical linkages among studies

# Chapter 2. Literature Review

## 2.1 Organizational Learning and Corporate Innovation

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. In order for a firm to actively cope with changes in the external environment, it is necessary to make efforts not only for investment in internal R&D activities but also for organizational learning about new technologies and knowledge that exist outside the firm. This section briefs various discussions of previous studies on corporate strategies for organizational learning.

### 2.1.1 Exploration and exploitation

Many researchers working on strategic management and organization theory have used March's (1991) ‘exploration-exploitation framework’ to describe organizational learning

activities for corporate innovation. According to March (1991, p. 71): “Exploration includes things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, innovation. Exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, execution.” Specifically in corporate theory, exploration refers to activities that create new knowledge that a firm does not possess. A firm seeking exploration attempts to search and acquire unfamiliar and novel technologies and resources, aiming to generate variation. Because of this nature, exploration is characterized by both high uncertainty and slow performance in learning outcomes. However, in the long run, organizations are able to create more radical innovations. Contrary to this, exploitation refers to activities that create innovations by utilizing the knowledge already held by the firm. It focuses mainly on the enhancement of the efficiency and productivity of the firm activity. These properties make exploitation relatively fast, efficient and predictable in terms of performance, however, it tends to be limited to short-term gradual innovation (March, 1991; Levinthal and March, 1993; Duncan, 1976; Eisenhardt and Martin, 2000; Tushman and O'Reilly, 1996).

Since the concept of exploration and exploitation has been established, research has been actively conducted on the ambidexterity strategy, in which firms pursue both short-term survival and long-term growth by combining these two organizational learning activities (Hoang and Rothaermel, 2010; Lavie, Stettner, and Tushman, 2010; Lavie, Kang, and Rosenkopf, 2011; Stettner and Lavie, 2014; Raisch and Birkinshaw, 2008). To pursue organizational ambidexterity, firms need to balance exploitation and exploitation. The most

representative balancing methods are organizational and temporal separation. Organizational separation involves creating exploration-oriented units (e.g., an independent research lab or CVC unit) to work separately from other departments primarily focusing on exploitation-oriented activities (e.g., manufacturing plant or sales forces) (Hill and Birkinshaw, 2014). Temporal separation, on the other hand, refers to the balancing method that firms undertake exploration and exploitation over time (Puranam, Singh, and Zollo, 2006).

### 2.1.2 Dynamic capabilities, ambidexterity, and real options

As an explanation for such ability to adapt to changing environments, Teece et al. (1997, p.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, Birkinshaw, Probst, and Tushman, 2009; Tushman and O'Reilly, 1996).

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 incumbent firms to create multiple strategic options.

For incumbent 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 incumbent 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 incumbent 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 corporate venture capitals (CVC) (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; Mowery, Oxley, and Silverman, 1998). Mowery et al. (1998) and Giuri et al. (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 et al. (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 Corporate Venture Capital and Organizational Learning

In recent years, CVC investments in entrepreneurial new venture companies have gained popularity as an organizational learning strategy for incumbent firms that attempt to approach various new technologies (Gompers and Lerner, 2000; Keil, 2004; Dushnitsky and Lenox, 2005a; Wadhwa and Kotha, 2006). CVC investments are small equity investments made by incumbent firms, not professional investment companies, in early-stage start-up companies (Dushnitsky and Lenox 2005; Gompers and Lerner 2000). Compared to general independent venture capital (IVC) investment (Block and MacMillan, 1993), CVC investments are characterized not only by financial returns but also strategic objectives as incumbent firms investing in start-ups from a broad range of technology sectors can seize an opportunity to access their diverse knowledge pools, learn about

emerging industries and technologies, and identify the possibility of technological discontinuities (Maula, Keil and Zahra, 2013). Table 2-1 shows a comparison of CVC and IVC (Alvarez-Garrido and Dushnitsky, 2016). Subsequently, following section looks at previous research on organizational learning activities through CVC investments.

**Table 2-1.** A comparison of corporate and independent venture capitalists

| | **CVC** | **IVC** |
|---|---|---|
| **Definition** | An established firm undertaking minority equity investment in entrepreneurial ventures | An investor dedicated to undertaking equity investment in entrepreneurial ventures |
| **Investor description** | A corporation with one or more lines of business. Investment responsibilities lie with CVC program | A dedicated financial investor |
| **Scope** | Investment activity is not the main business of the investing firm. Annual investment amounts are a fraction of total revenues or assets of the investing firm | Investment activity is the sole business of the independent VC. Broadly speaking, IVC's assets (capital under management) are fully allocated toward investment in entrepreneurial ventures |
| **Structure** | Various legal and organizational structures. The CVC team is based within a business unit or headquarters. The parent corporation is the sole source of capital, and also provides support via access to R&D, business, and other corporate functions | Limited liability partnership (LLP). General partners (GP) raise funds from limited partners (LP) and then invest the capital in entrepreneurial ventures |
| **Funding (assets and** | Professional investment team, capital provided by the corporation, access to | Professional investment team, and financial capital committed by the LPs |

| | | |
|---|---|---|
| **resources)** | corporate infrastructure including R&D as well as manufacturing facilities, dedicated units to manage national and international regulatory demands, and global sales force with deep ties to medical doctors, hospitals, and other drug buyers (e.g., HMOs) | |
| **Personnel size and background** | Parent firm: Total number of CVC parent corporations ～ 60,000. These include thousands of highly specialized personnel in R&D, sales and marketing, as well as legal and regulatory areas<br>CVC unit: Average number of personnel within the CVC unit is 4.3. Their background usually consists of corporate personnel, and may also involve former VC professionals, former entrepreneurs, or investment professionals | Average number of GP personnel is 4.7. Their background usually consists of investment professional, former entrepreneurs, sometimes with advanced Ph.D. background |

Source: Alvarez-Garrido and Dushnitsky (2016)

### 2.2.1 CVC investments for creating diversified technological options

Compared to other external learning methods such as M&A, strategic alliance, and joint venture, one of the relative advantages of CVC investments is that CVC investors can access to more diverse knowledge pools. Incumbent 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) pointed out that CVC investment is a typical example of a strategic investment for option creation. Table 2-2 shows various innovation methods of sourcing and integrating external technologies, with their uses, advantages, and limitations (Markham, Gentry, Hume, Ramachandran, and Kingon, 2005)

**Table 2-2.** Innovation methods of gaining access to new technologies

| Innovation methods | Uses | Advantages | Limitations |
|---|---|---|---|
| **Central R&D Activities** | Maintain proprietary position with senior corporate oversight | Control over projects and progress, with focus on radical and/or cross-SBU innovation | Limited to internal expertise and resources. May not be connected to customer needs |
| **Strategic Business Unit R&D** | Close contact with customer needs | Fast response to customer needs | More likely to produce Incremental improvements |
| **Development Outsourcing** | Develop complex products needing a broader set of skills or to reduce costs of development | Other companies bear the cost of developing technology for your use | Incomplete control over project<br>May be available to competitors |
| **Alliance & Partnerships** | Cooperation to gain access to technology or markets—not as extensive as joint | Access to other's technology without all the cost and formality of a JV | Difficulty assessing partner inputs<br>Full commitment may be lacking. |
| **Joint Ventures** | Open up new opportunities accessing very new technology | New structure able to act independent of parents | Difficulty in maintaining an agreement |

| | | | |
|---|---|---|---|
| | and markets | | |
| **University Research** | Investigate fundamental technical capabilities | Explore new avenues to problems | Result of project may not be readily usable |
| **Direct Investment in Start-up Company** | Control or acquire new markets or technologies without taking all the risk of development | Have more control over the development and application of the technology | May not see as many new technologies as a VC fund.<br>Higher financial risk |
| **Invest in VC Fund as a Limited Partner** | Have a window on new markets and technologies.<br>Identify possible acquisitions, customers, competitors, suppliers | See many new technologies develop over time.<br>Lower financial risk | No control over the development or application of the new technology |

Source: Markham et al. (2005)

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'[2] 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)[3] also shows similar results. According to the survey, about 65% 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 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

[2] Dushnitsky, G., Haemming M., and Tharp. D. (2008). Global Corporate Venture Capital Survey 2008-09: Benchmarking Programs and Practices. *Supported by Ernst & Young.*
[3] MacMillan, I., Roberts E., Livada V., and Wang A. (2008) Corporate Venture Capital (CVC): Seeking Innovation and Strategic Growth. *Supported by National Institute of Science and Technology (NIST).*

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. Table 2-3 shows a comparison of CVC and strategic alliances (Dushnitsky and Lavie, 2010)

**Table 2-3.** A comparison of CVC and strategic alliances

| | **CVC** | **Strategic Alliances** |
|---|---|---|
| **Definition** | A minority equity investment by an established fi rm in an entrepreneurial venture that seeks capital for growing its operations | A voluntary arrangement between independent firms that share and exchange resources in the co-development or provision of products, services, or technologies |
| **Main Objectives** | Sponsoring an emerging or complementary technology | Cost sharing, joint development, resource access, and market entry, among others |
| **Scope** | The agreement covers the whole operation of the funded venture and none of the established firm's operations | The agreement covers joint operations whose specific scope is limited relative to the partners' independent operations |
| **Activities** | The funded venture performs value chain activities on a stand-alone basis | Value chain activities are performed interactively by both partners |
| **Funding** | Only the established firm makes the financial investment | Both partners may make financial investments |
| **Ownership** | The established firm buys a minority equity stake in the funded venture and may exert influence on its corporate decisions | Most alliances do not involve equity, with joint ventures drawing major equity stakes from the partners that directly influence the operations of the new |

| | | |
|---|---|---|
| | | venture |
| **Timing** | The relationship is established during specific investment rounds, often early in the life cycle of the privately held funded venture | The relationship can be initiated throughout the life cycles of both partners |
| **Setting** | The established firm is typically joined by independent VC funds that also invest in the funded venture as part of the syndication | Most alliances are dyadic and do not involve independent VC funds |
| **Role asymmetry** | A clear distinction between the investor and the recipient of funds | Both partners invest resources and expect monetary returns on their investments |
| **Governance** | The established firm manages CVC via a dedicated VC arm or a corporate business development unit | Alliances are managed by a dedicated alliance function or by business units of the respective partners |

Source: Dushinitsky and Lavie (2010)

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 incumbent 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 incumbent 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.

### 2.2.2 CVC portfolio diversity

Most prior CVC literature considered CVC investments as individual and independent investments (Gompers and Lerner, 2000; Keil, 2004; Dushinitsky and Lenox 2005; Wadhwa and Kotha, 2006). In recent years, and similar to the trend of analyzing networks and portfolios of strategic alliances as opposed to single alliance deals (Lavie, 2007; Duysters et al. 2012; Oerlemans, Knoben, and Pretorius 2013; Van de Vrande 2013;

Marhold and Kang, 2016), more recent studies on CVC tend to consider an integrated CVC investment portfolio, which is composed of several investment deals (Lin and Lee, 2011; Lee and Kang, 2015; Yang, Narayanan and De Carolis, 2014; Wadhwa, Phelps and Kotha, 2016; Yang, Chen and Zhang, 2016). Wadhwa, Phelps, and Kotha (2016) argued that portfolio investments in various start-ups will satisfy diverse strategic needs and create greater synergy. These portfolio investments may reflect the various strategic intentions of the investor firm or may be overlapped investments serving a single strategic intent.

Among the portfolio characteristics of CVC investment, portfolio diversification is the most interesting feature of recent researchers, because the effect of CVC investments varies depending on how the corporate investor diversifies its investment portfolio. Companies that make investments by constructing a less diversified portfolio can increase the depth of knowledge gained by investment firms because they are exposed to similar knowledge multiple times. In CVC manner, investments in similar technology fields also make the learning process more efficient and allow corporate investors to better generalize and identify information in similar cases (Haleblian and Finkelstein, 1999). Moreover, as the CVC parent firms acquire knowledge in a specific field that is highly related to their existing knowledge, the process of knowledge integration later can be relatively facilitated.

On the other hand, operating an investment portfolio made up of companies from diverse technology fields enables corporate investors to access more diverse knowledge needed for innovation without duplicated knowledge (Greve, 2007), and to create more solutions by recombining various knowledge (Fleming, 2001). The diverse knowledge

gained from various knowledge sources enables the investing firm to create various options that can be used in the future, thus enabling flexible responses of companies to unpredictable environmental changes (March 1991; Brown and Eisenhardt 1997, Van de Vrande and Vanhaverbeke 2013). Moreover, corporate investors who operate diversified portfolios can increase relative absorptive capacity in an effort to understand and apply different knowledge (Cohen and Levinthal 1990). Since relative absorptive capacity is a dynamic concept rather than a static concept, it becomes stronger with various experiences with unfamiliar knowledge, and makes it possible for the firms to carry out learning more effectively even when new technological changes are encountered in the future (Yang et al., 2014). In fact, according to a 2008 survey by the National Institute of Standards and Technology (NIST) in the United States, more than 55% of CVC investors state that they want to use CVC investment to find new directions and explore various technologies and emerging markets. To achieve these goals of CVC investments, securing portfolio diversification is very important.

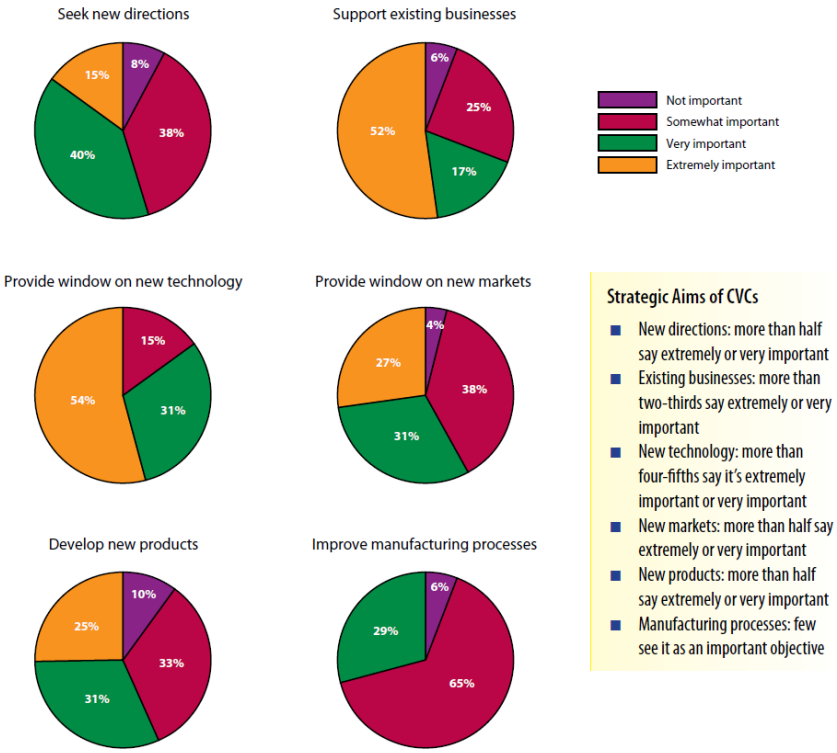


**Figure 2-1.** What strategic aims are important to CVCs?
(Source: MacMilan et al (2008) – NIST CVC Report)

Wadhwa et al. (2016) showed that CVC portfolio diversity has an inverted U-shaped relationship with the investor firm's innovation performance. They argued that by acquiring non-overlapping knowledge, corporate investors can create new innovations through recombination. The research empirically showed not only the value of the individual investee companies that make up the portfolio is important, but also the synergy created through mutual relations between them. Yang et al. (2014) mathematically identified the relationship between CVC portfolio diversification and the complex firm value of a corporate investor and confirmed it through empirical analysis. The authors divide the

value of CVC investment into financial value and strategic value, and added portfolio effect which is synergy effect among companies in the portfolio. The empirical analysis results show that CVC portfolio diversification has a U-shape relationship with the firm value of the corporate investor. In other words, it can be said that the synergetic impact caused by the interactions among the companies in the investment portfolio can give a greater impact than the sum of the strategic impacts that can be achieved through each company. Moreover, Lee and Kang (2015) empirically analyzed the relationship between CVC investments and the technological diversification of CVC parent firms. According to their analysis, the amount of CVC investments and the level of CVC portfolio diversity both have an inverted U-shape relationship with the technological diversification of the CVC parent firm. In other words, they showed that assembling and operating diversified CVC portfolios up to a certain level can help increase the variety of technological innovations created by the parent firms.

Compared to the number of studies on the relationship between CVC portfolio diversity and financial and technical performance of corporate investors (e.g., Yang et al., 2016), research on the antecedent factors that determine CVC portfolio diversity is still lacking. In the real world, the level of CVC portfolio diversity quite varies between corporate investors. Therefore, a better understanding of the origins of these differences is needed in order to further develop the academic understanding of CVC strategies, and to offer valuable managerial implication for corporate investors. In order to fill the logical gaps in the existing research, this study investigates the antecedents of CVC portfolio diversity

from the perspective of the ‘managerial attention’ of corporate investors.

### 2.2.3 Managerial attention and CVC investment decision

Many organizational scholars have focused on managerial attention as a key factor in determining corporate strategic behavior (Simon, 1947; Ocasio, 1997; Jones and Baumgatner, 2005; Thomton, 2004). Ocasio (1997) redesigned the attention perspective on the administrative behavior of Simon (1947). He defined managerial attention as “the distinct focus of time and effort by the firm on a particular set of issues, problems, opportunities, and threats and on a particular set of skills, routines, programs, projects, and procedures (Ocasio, 1997, p. 188)”, and presented three principles of attention: 1) focus of attention, 2) situated attention, and 3) structural distribution of attention. First, in the perspective of ‘focus of attention’, decision makers select and focus on a limited set of issues and solutions that are deemed necessary and appropriate from many of the strategic issues and solutions that exist within and outside of the firms. Therefore decision makers’ strategic behaviors will be determined by the issues and solutions what they choose. The situated attention is the view that decision makers' attention is formed by the firm's procedural and communicational channels, and the perspective of structural distribution of attention views that the attention of decision makers participating in the channels is generated by rules, resources, players and social positions of the firm.

The strategic decisions that can be made by managerial attention of firms include the

entry to new technology or emerging market (Eggers and Kaplan, 2009) or new production development (Nadkarni and Chen, 2014), and various external knowledge searching strategies (Tseng, Fang, and Chiu, 2011). In terms of portfolio strategies, Barnett (2008) especially emphasized the importance of managerial attention in the option portfolio management. Barnett (2008) argued that firms identify various possibilities before making strategic choices and construct a strategic option portfolio by selecting projects that fit their attention. Moreover, Tseng et al. (2011) argues that knowledge search strategies as problem-solving activities are also determined by the managerial attention of firms, and empirically analyzed the impact of decision makers' attention on explorative search on the company's innovative competence.

Expanding the arguments of Barnett (2008) and Tseng et al. (2011), I infer that CVC investment as an external knowledge sourcing strategy is also influenced by the managerial attention of the firm, and, in particular, CVC portfolio diversity is influenced by decision maker's attention in terms of option management (Maula et al., 2013; Yang et al., 2016). In this perspective, if the managerial attentions of the corporate investors are closer to the knowledge sourcing of the various technology fields, they will operate a diversified portfolio. On the contrary, if the corporate investors want in-depth knowledge sourcing of a small number of specific areas, they can operate a specialized portfolio. Therefore, in order to understand how CVC portfolio diversity is determined, it is reasonable to analyze the antecedent factors affecting the managerial attention of the corporate investor.

### 2.2.4 CVC operation and practical decision making issues

Serval researchers used methodologies such as questionnaires and in-depth interviews to discuss practical issues related to CVC investment operations. Battistini, Hacklin, and Baschera. (2013) conducted in-depth interviews and surveys of 48 global leading CVCs in five business segments; 1) technology, media, and telecommunication, 2) industrial goods and services, 3) pharma and chemicals, 4) consumer goods and retail, and 5) financial services. Based on the opinions of managers who make decisions about CVC investment, this paper deals with the strategic goals of the CVC investment, the type of investment organization and how it operates. According to the results of the survey, 56% of respondents are investing in learning in the adjacent business area, 27% are investing in CVC to strengthen their current core business domain skills and knowledge, and only 17% are investing to learn wholly new technology fields (white space). These results suggest that CVC investors focus on both exploitative learning and explorative learning, and indeed, they are investing more in close to exploitative learning.

In addition, Battistini et al. (2013) also focused on the operational aspects of the CVC investment organization and discussed the role of the autonomy of decision making authority. The authors pointed out that the CVC investment organization exists as an internal department or as a subsidiary outside the enterprise. As a result of survey, 31% of the responding firms operate CVC investment departments within the organization, thus their investment managers are making limited investments through thorough internal audits

rather than autonomous investments, while the remaining two-thirds are operating their own assets and making autonomous investments. The autonomy granted to the CVC dedicated unit not only affects the degree of freedom of investment operation but also has an important effect on the selection of target companies and whether to focus on investment in the short term or on a long term basis.

Battistini et al. (2013) categorized CVC investment management into three models such as 'strategic model', 'financial model', and 'balanced model' by reflecting these strategic goals and characteristics of organization operation. The strategic model focuses on the development of company ideas and the acquisition of external knowledge to achieve the goals of creating strategic options and accelerating innovation performance. This model tends to be managed by the R&D department or the CTO because it focuses on forming a partnership at the technology level rather than a financial approach. In particular, in this model, since a CVC dedicated unit exists as a part of internal departments or R&D organizations, it is given a relatively small level of decision making autonomy. Next, the financial model focuses on maximizing the use of industrial expertise and channels for business diversification and financial gain. In this model, the CVC dedicated unit is often in the form of a subsidiary outside the organization and has a relatively high degree of autonomy because it is in a separate decision process with the parent firm. Finally, the balanced model pursues both the strategic value of the investment and the financial gain, so that it attempts to build a strategic ecosystem by expanding the window to new technologies and business areas. In this case, the CVC dedicated unit operates

independently outside of organization but maintains a certain degree of relationship with the parent firm to make a strategic investment. In this model, the CEO or CFO of the parent firm often has the ultimate decision-making power over the investment. Table 2-1 shows the characteristics of each organizational models for CVC activities.

**Table 2-4.** Organizational models for corporate venturing activities

| | **Main Rationale** | | |
|---|---|---|---|
| | **Strategic** | **Financial** | **Balanced** |
| **Scope** | Option generation and acceleration of innovation | Diversification and financial return | Strategic value and financial return |
| **Objectives** | - Establish entrepreneurial climate<br>- Foster internal creation of ideas<br>- Incorporate external intelligence | - Derive financial profit by leveraging industry expertise and channels | Gain window on technology/business models<br>Develop strategic ecosystem<br>Offer attractive returns |
| **Guiding Principles** | - Interest in technology defines boundaries of investments<br>- Partnership development is primary, financing secondary | - Industry expertise and networks define boundaries of investments<br>- Independent internal assessment process and ratification provides evaluation of investments | Corporate strategy defines boundaries of investments<br>Evaluation is supported by corporate functions and expertise |
| **Structure** | Incorporated in parent company | - Independent entity with separate | Separate entity with parent exercising |

| | | | |
|---|---|---|---|
| | - As division<br>- Within R&D<br>- Within business units | decision-making process<br>- Limited/general partnership structure common | control at various levels<br>Advisory board<br>Investment committee<br>Binding mandate |
| **Reporting Line** | - R&D / CTO<br>- Business units | - Limited partners of independent entity | CEO<br>Investment committee including CFO |
| **KPIs** | - # of collaborations with business units<br>- Rate of technology transfer<br>- # of commercial relationships | - Internal rate of return<br>- Contribution to corporate revenues<br>- Valuation of portfolio companies | IP position<br>Strategic relationships derived<br>Initial investment to fair market value = yield |

Source: Battistini et al. (2013)

In addition, Markham et al. (2005) categorize the decision-making process of CVC investments into several categories, which summarize what investors should consider in each case. It provides practical advices that practitioners can refer to by dealing with decision-making issues at various levels, including the strategic goals of CVC, the style of investment, the governance and financial issues of the investment organization, the issues of intellectual property rights, and human resource management issues. Table 2-2 show the practical decisions and possible considerations for CVC investments

**Table 2-5.** Investment decisions and considerations

| Decisions Needed | Considerations |
|---|---|
| **Strategic objectives** | |
| Possibilities include: growth in current markets; window on world; value chain expansion; risk mitigation; outsourcing technology or R&D | Typically firms have multiple objectives. However, managers need to be clear as to what the single highest priority is and then optimize around that objective. |
| **Internal vs. External investments** | |
| - Leveraging internal ideas<br>- Expanding knowledge pool by going outside | VC firms are no smarter than corporations but may offer different views on ″white space″ |
| **Investment Style** | |
| - Invest in fund or company<br>- Stage at which to invest<br>- Minority vs. majority investment<br>- Criteria for investment<br>- Risk tolerance | Investing in venture finds can give direct involvement in business growth. Funds give a broader window on the world.<br>For direct investments, managers must balance control vs. liability. |
| **Governance** | |
| - Time frame for expected deliverables<br>- Who reviews technology (centralized vs. external)?<br>- Exit scenario<br>- Who makes decisions on investment?<br>- Organizational structure (centralized, BU, geographic), number of people dedicated to corporate ventures group vs. borrowed from businesses | Need to establish clarity on selection criteria<br>Must consider transfer and buy-in with the business units<br>Metrics are important for deciding when to get out of an investment<br>Structure of CV group and its oversight board anre critical for driving desired outcomes |
| **Financial issues** | |
| - Who pays (business unit, corporate, R&D)?<br>- How is funding decision made?<br>- Who claims profits (losses)?<br>- Fixed budget vs. case-by-case decision | Funding structure will drive level of ongoing commitment as well as drive expectations around quarterly results vs. long-term investment. |

| | |
|---|---|
| - Size of fund<br>- Accounting practices | |
| **Intellectual properties** | |
| - Approach to handling IP transfer issues<br>- Model for accessing technology (license, be a customer, etc.)<br>- Strategy around IP<br>- What is hoped to attain | Need t erect firewalls so that no legal issues or constraints become surprises downstream |
| **Human Resource Issues**<br>- Incentives, rewards<br>- Keep your option to go back to the parent company after joining the startup? | - Decide how te get the right type of person (i.e., risk taker) when corporations often value other characteristics<br>- Decide how to compensate so that employees feel the urgency of start-up while also sharing the potential reward<br>- Must manage how the rest of the corporation will perceive venture compensation |

Source: Markham et al., (2005)

# Chapter 3. Technological Diversification through CVC Investments[4]

## 3.1 Introduction

To actively cope with this uncertainty and changing circumstances, incumbent 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 incumbent 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

[4] An earlier version of this chapter has been published in *Industry and Innovation*

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 incumbent 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, incumbent 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). Several reports and academic papers which conducted some surveys or case studies have discussed the role of CVC investments as a catalyst of technological window expansion (MacMillan et al., 2008 – NIST CVC Report; Dushnitsly et al., 2008 – Ernst & Young Global Corporate Venture Capital Survey, Battistini et al., 2013; Markham et al., 2005). However, most literature that has empirically analyzed 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 between the survey results of practitioners and the flow of empirical research in academia, I raised a research question; "does CVC investment influence on the expansion of investor firm's technological diversity?", and tried to empirically examine the

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

## 3.2 Research hypotheses

### 3.2.1 CVC investments and technological diversification

In the literature review section, I 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.

The most representative firm that is increasing the technological diversity of the knowledge pool through CVC investment is Google. Google has evolved from being a technology firm that originally offered an Web-based search engine to a diversified business in a variety of business areas, including software, Internet, advertising, and media. Recently, Google has been expanding its technological boundary from IOT (Internet of Things) and AI (Artificial Intelligence), which is highly related with Google's core technologies, to some unrelated business area such as logistics, robotics, and bio-health care technologies.

The fundamental reason why Google is actively trying to expand its technology

boundary is to diversify its revenue structure to respond to future market change more stably and flexibly. In mid 2000's, Google had a monetized revenue structure focused solely on the Internet advertising industry, and suffered a growth slowdown in the aftermath of the global financial crisis. In order to gain more strategic options in this uncertain future market environment, Google has created a diversified technology portfolio through aggressive investments.

The driving force behind Google's ability to construct such a diversified technology portfolio was in active CVC investment activities targeting venture start-ups in the various cutting-edge technology industry. Since the mid-2000s, Google began investing in start-ups, and in 2009, it launched Google Ventures which is a specialized subsidiary of CVC investments. Google Ventures' main investment objective is to explore new markets and diversify businesses. Google Ventures has invested in disruptive innovations that have escaped existing trends and invested in a variety of technologies that are less relevant to each other, broadening their knowledge to cope with future changes. For example, prior to the popularization of smartphones, Google was able to respond to changes from the web-based ecosystem to mobile-based ecosystem by acquiring Android, the startup that had mobile OS development technology. Recently, Google Ventures continues to expand its knowledge boundaries by investing in a variety of technology areas, including mobile, internet, and software technologies, as well as renewable energy, bio-health care, and organic agricultural products.

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 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, I suggest the following hypothesis:

***Hypothesis 3-1****: The technological diversity of a CVC investor firm has a curvilinear (inverted U-shaped) relationship with the total amount of its CVC investments.*

### 3.2.2 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 incumbent 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.

A good example of a corporate investor that has acquired a variety of technological knowledge through diversified CVC portfolio management is the case of GS Home Shopping in Korea. GS Home Shopping is the leading firm in the Korean domestic home

shopping industry and is focused on TV home shopping business. GS Home Shopping is regarded as one of the largest corporate investors that are actively investing in CVC even though its industrial base is not a high-tech industry. The reason why GS Home Shopping get the interest in investing in venture start-ups was also due to the slowdown in growth of the TV home shopping industry, which was the original industrial base. GS Home Shopping began investing in CVC in 2011, when the home shopping environment began to shift from TV to the Internet and mobile, and in 2014, it established a CVC investment dedicated division in the Strategic Headquarters. From 2011 to the end of 2016, GS Home Shopping invested KRW 92.4 billion in CVC investment.

Similar with Google Ventures, GS Home Shopping's CVC investment direction is set to acquire knowledge in a wider variety of technological fields. In addition to e-commerce, which can directly generate synergies with core business of GS Home Shopping, it also invests in various business fields such as used car transaction apps, electronic book distribution platform, remittance service app, indoor air quality measurement IOT technology and video streaming technology. In fact, GS Home Shopping has gained considerable strategic benefits in the mobile business through its newly acquired technologies through such CVC investments. In particular, a case of investing Buzzni, a startup that provided services to users by collecting movie reviews, is a prime example of successful investment. GS Home Shopping launched 'Home Shopping Moa’ mobile apps service, which combines home shopping product information and appraisal through collaboration with Buzzni. As a result, GS Home Shopping has been able to more easily

deliver home shopping information to its customers through smartphones, enabling it to secure a younger customer base through mobile shopping. As of 2016, total sales of Home Shopping Moa apps accounted for KRW 111.4 billion, a year-on-year growth rate of 280%. GS Home Shopping's mobile sales also grew 22% year-on-year to KRW 379.7 billion in 4Q 2016.

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, andWu2006). 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 incumbent 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, I suggest the following hypothesis:

***Hypothesis 3-2****: 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.*

### 3.2.3 Absorptive capacity and technological diversification

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, I 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:

***Hypothesis 3-3****: 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 3-4****: 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.*

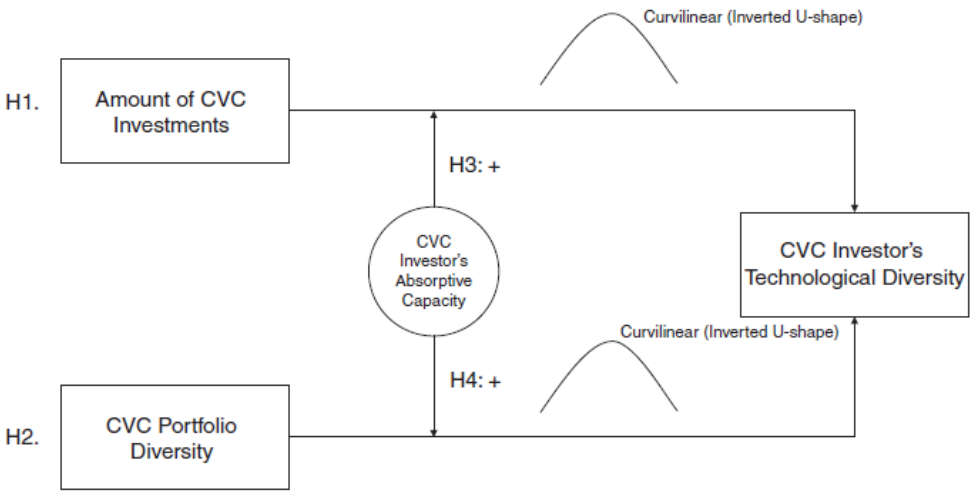


**Figure 3-1.** Conceptual Model for Chapter 3

The conceptual diagram in Figure 3-1 shows the relationships between the suggested hypotheses.

## 3.3 Methods

### 3.3.1 Data and sample

I test the 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, I suppose that high-tech firms have more incentives to attempt explorative learning through CVC Investments. I carried out the selection and sampling of the data according to the following process:

First of all, I 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 the sample of investor firms, I 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 me 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, I 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, I used patent class data which is provided by the U.S. Patents and Trademarks Office (USPTO) database.

In this study, I 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 applied for 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. Final data-set of this research contains 1313 firm-year observations from 97 different CVC investors but is unbalanced because of some missing data during the period.

### 3.3.2 Variables

#### 3.3.2.1 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. This 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, I 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 me the better show the temporal order of cause and effect.

Firm A's 1998 Technological Diversity = 1 (Only 709 Class)

Firm B's 1998 Technological Diversity = 4 (235, 370, 705, 709 Classes)

| Firm Name | Year | primary id | secondary id |
|---|---|---|---|
| Firm A | 1998 | 709 | 223 |
| Firm A | 1998 | 709 | 242 |
| Firm A | 1998 | 709 | 223 |
| Firm A | 1998 | 709 | 242 |
| Firm B | 2009 | 235 | 235/487 |
| Firm B | 2009 | 235 | 235/382 |
| Firm B | 2009 | 235 | 235/375 |
| Firm B | 2009 | 705 | 705/52 |
| Firm B | 2009 | 370 | 370/39542 |
| Firm B | 2009 | 709 | 709/229 |
| Firm B | 2009 | 370 | 370/39521 |

**Figure 3-2.** 3-digit Patent Class Coding Example

#### 3.3.2.2 Independent variables

This 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, I 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 me 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, I 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, I want a higher value of the independent variable to signal a higher degree of diversity and thus the reciprocal of the Herfindahl Index was utilized (Leten et al., 2007).

$$Industrial\ Diversity\ of\ Portfolio\ Companies_{(i,t-1\ to\ t-3)} = \frac{1}{HI.Industry_{(i,t-1\ to\ t-3)}} = \frac{1}{\sum_{k=1}^{n} s_k^2}$$

where i=firm id and k=k$^{th}$ industry class.

The third independent variable is the investor firm's *Absorptive Capacity*, which I expect to moderate the relationship between the two previous independent variables and dependent variable. The absorptive capacity of companies is measured by focal firm's R&D intensity. Specifically, I 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, Wu, Chang, Wang, and Lee, 2012).

$$Absorptive\ Capacity_{(i,t-1\ to\ t-3)} = \frac{R\&D\ Expenditure_{(i,t-1\ to\ t-3)}}{Total\ Assets_{(i,t-1\ to\ t-3)}}$$

#### 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 me to add a number of control variables. First, I controlled for previous *M&A Experience* and *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 I 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, I 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 I 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, I

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 I also controlled for firm size (firm i's total sales in year t-1).

*Fixed Effects of Industry* is an important variable that I 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 I control for the fixed effects of the five different industries in the 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 venture capitals (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, the control variable is defined as the number of VCs in each

investment round that the focal firm i participates in.

Firm C's 1996
Quality of Portfolio Companies = 3

Firm C's 1997
Quality of Portfolio Companies = 6
(3+3)

Firm C's 1998
Quality of Portfolio Companies = 13
(3+3+1+6)

| CVC Firm | Portfolio Company | Year | # of Investors (@ this round) |
|---|---|---|---|
| Firm C | Company A | 1996 | 3 |
| Firm C | Company A | 1997 | 3 |
| Firm C | Company B | 1997 | 3 |
| Firm C | Company C | 1998 | 3 |
| Firm C | Company D | 1998 | 3 |
| Firm C | Company E | 1998 | 1 |
| Firm C | Company F | 1998 | 6 |

**Figure 3-3.** Quality of Portfolio Companies Coding Example

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

### 3.3.3 Statistical model

*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, I decided to use a negative binomial regression model which is one of the nonlinear model commonly employed to avoid heteroskedasticity problems (Hausman et al., 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 the dependent variable (135.089) is larger than its mean value (104.613), I 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, I conducted a Hausman test (Hausman et al., 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 the panel data.

I assigned 1 year to 3 year time lags on most of 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, 2005a; 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, 2005a). Thus I also expect that CVC investment would only affect the investor's technological diversity after several years, prompting me to employ time lagged variables.

**Table 3-1.** Variable descriptions

| Variables | Measures |
|---|---|
| Technological Diversity of CVC Investors | Cumulative count of patents classes newly applied for by focal firm in 3 years after CVC Investment |
| Total Amount of CVC Investments | Natural log of total annual CVC investment in last 3 years |
| Industrial Diversity of Portfolio Companies | Inverse value of Herfindahl Index of portfolio companies' industry distribution in last 3 years |
| Absorptive Capacity | Natural log of cumulative R&D expenditure in last 3 years versus total assets in last 3 years |
| M&A Experience | Cumulative experiences of M&A in last 3 years |
| Alliance Experience | Cumulative experiences of Alliances in last 3 years |
| Cumulative Patent Stock | Natural log of cumulative patent stock in last 5 years |
| Firm Size | Natural log of total sales in last year |
| Quality of Portfolio Companies | Cumulative number of co-invested VCs in last 3 years |

## 3.4 Results

### 3.4.1 Descriptive statistics and correlations

Table 3-1 represents the descriptive statistics of all the variables used in this 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, I decided to use a negative binomial model for 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 .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 .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.

**Table 3-2.** Descriptive statistics and correlations matrix of the variables

| | Variable | Mean | S.D. | Min | Max | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Technological Diversity of CVC Investors | 104.613 | 135.089 | 0 | 627 | 1.000 | | | | | | | | |
| 2 | Total Amount of CVC Investments | 9.123 | 8.964 | 0 | 22.290 | 0.205 | 1.000 | | | | | | | |
| 3 | Industrial Diversity of Portfolio Companies | 3.769 | 7.942 | 0 | 74.798 | 0.241 | 0.545 | 1.000 | | | | | | |
| 4 | Absorptive Capacity | 0.691 | 0.240 | 0 | 3.714 | 0.162 | 0.143 | 0.070 | 1.000 | | | | | |
| 5 | M&A Experience | 8.713 | 10.747 | 0 | 85 | 0.328 | 0.328 | 0.477 | 0.045 | 1.000 | | | | |
| 6 | Alliance Experience | 18.571 | 35.475 | 0 | 339 | 0.323 | 0.025 | 0.144 | 0.046 | 0.447 | 1.000 | | | |
| 7 | Cumulative Patent Stock | 4.957 | 2.764 | 0 | 9.942 | 0.771 | 0.344 | 0.315 | 0.282 | 0.365 | 0.314 | 1.000 | | |
| 8 | Firm Size | 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 | 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=1,314. Dummy variables were excluded.

### 3.4.2 Regression results

Table 3-3 shows the results of the negative binomial regression model. For this study, I 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* and *Industrial Diversity of Portfolio Companies* to test 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 full model that includes all variables.

Hypothesis 1 predicts a curvilinear relationship between the amount of CVC investment and technological diversity of the investor firm. In other words, I argue that as the company invests more resources on CVC, the diversity of the patent classes in which 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 ($p<.001$) and the squared term is negative and significant ($p<.001$). Therefore the empirical results support Hypothesis 1.

Hypothesis 2 predicts a curvilinear relationship between the portfolio diversity of CVC investment and technological diversity of the investor firm. I 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 ($p<.01$) and the squared term is negative and significant ($p<.01$). These results support Hypothesis 2.

Model 3 and 4 identify the moderating effects of the previous two independent variables and moderating variable, *Absorptive Capacity*, while Model 5 is the full model that includes all the variables. To uncover the moderating effect of *Absorptive Capacity*, I 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 ($p<.05$), whereas the interaction of the squared term and *Absorptive Capacity* is positive and insignificant ($p>.05$). While the interaction of the linear term in Model 5 is negative and insignificant ($p>.05$), the interaction of the squared term is positive and significant ($p<.05$). 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 Portfolio Companies* and *Technological Diversity of CVC Investors*. In the model, the interaction of the linear term and *Absorptive Capacity* is negative and significant ($p<.01$), whereas the interaction of the squared term and *Absorptive Capacity* is positive and significant ($p<.01$). 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.

### 3.4.3 Reverse causality

I 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, I reversed the temporal order of independent variable and dependent variable for Hypothesis 1. In other words, I set 'Technological Diversity of CVC Investors (t-1 to t-3)' as the lagged independent variable and 'Total Amount of CVC Investments (t to t+2)' as the lagged dependent variable, and performed regression analysis. In the results of the reverse-order regression analysis, shown in Table 3-4, I 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.

**Table 3-3.** Regression results (Negative Binomial Regression Models)

| ***Dependent Variable*** (Technological Diversity of CVC Investors) | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** |
|---|---|---|---|---|---|
| ***Control Variables*** | | | | | |
| M&A Experience | 0.007<br>(0.004) | 0.002<br>(0.004) | 0.001<br>(0.004) | 0.003<br>(0.004) | -0.003<br>(0.004) |
| Alliance Experience | 0.006***<br>(0.001) | 0.008***<br>(0.001) | 0.008***<br>(.001) | 0.007***<br>(0.001) | 0.007***<br>(0.001) |
| Cumulative Patent Stock | 0.367***<br>(0.013) | 0.354***<br>(0.012) | 0.352***<br>(0.011) | 0.352***<br>(0.011) | 0.352***<br>(0.011) |
| Firm Size | 0.055***<br>(0.012) | 0.050***<br>(0.011) | 0.043***<br>(0.012) | 0.044***<br>(0.011) | 0.044***<br>(0.011) |
| Quality of Portfolio Companies | 0.000***<br>(0.000) | 0.000**<br>(0.000) | 0.000**<br>(0.000) | 0.000**<br>(0.000) | -0.000**<br>(.000) |
| Industry Dummies | Included | Included | Included | Included | Included |
| _Cons | 1.383***<br>(0.061) | 1.109***<br>(0.077) | 1.101***<br>(0.077) | 1.095*<br>(0.076) | 1.118***<br>(0.078) |
| ***Independent Variables*** | | | | | |
| Total Amount of CVC Investments | | 0.143***<br>(0.031) | 0.139***<br>(0.035) | | 0.127**<br>(0.046) |
| (Total Amount of CVC Investments)$^2$ | | -0.018***<br>(0.005) | -0.015***<br>(0.004) | | -0.027**<br>(0.009) |
| Industrial Diversity of Portfolio Companies | | 0.084**<br>(0.029) | | 0.093***<br>(0.017) | 0.113***<br>(0.020) |
| (Industrial Diversity of Portfolio Companies)$^2$ | | -0.013**<br>(0.005) | | -0.024**<br>(0.009) | -0.031**<br>(0.011) |
| Absorptive Capacity | | 0.390***<br>(0.083) | 0.404***<br>(0.082) | 0.417***<br>(0.081) | 0.392***<br>(0.085) |
| Absorptive Capacity X Total Amount of CVC Investments | | | -0.072*<br>(0.035) | | -0.120<br>(0.073) |
| Absorptive Capacity X (Total Amount of CVC Investments)$^2$ | | | 0.017<br>(0.012) | | 0.011*<br>(0.005) |
| Absorptive Capacity X Industrial Diversity of Portfolio Companies | | | | -0.069**<br>(0.024) | -0.152**<br>(0.053) |
| Absorptive Capacity X (Industrial Diversity of Portfolio Companies)$^2$ | | | | 0.025**<br>(0.009) | 0.035**<br>(0.012) |
| Observations | 1313 | 1313 | 1313 | 1313 | 1313 |
| Log-Likelihood | -4409.60 | -4366.23 | -4268.95 | -4279.49 | -4161.84 |
| Log-likelihood Ratio $\chi^2$ | 260.24 | 319.77 | 331.22 | 322.74 | 350.93 |

Note: N=1,313. ***p<0.001; **p<0.01; *p<0.05

**Table 3-4.** Reverse causality test (GLS Regression Models)

| ***Dependent Variable*** (Total Amount of CVC Investments) | **Model 6** | **Model 7** |
|---|---|---|
| ***Control Variables*** | | |
| M&A Experience | 0.065*** (0.008) | 0.063*** (0.008) |
| Alliance Experience | -0.009*** (0.003) | -0.009*** (0.003) |
| Cumulative Patent Stock | 0.220*** (0.040) | 0.277*** (0.056) |
| Firm Size | 0.141* (0.057) | 0.168** (0.058) |
| Quality of Portfolio Companies | 0.002*** (0.001) | 0.002*** (0.001) |
| Industry Dummies | Included | Included |
| _Cons | 1.264 (1.276) | 0.969*** (1.293) |
| ***Independent Variables*** | | |
| Technological Diversity of CVC Investors | | -0.002 (0.003) |
| (Technological Diversity of CVC Investors)$^2$ | | -0.000 (0.000) |
| Observations | 1313 | 1313 |
| Overall $R^2$ | 0.259 | 0.265 |
| Wald $\chi^2$ | 276.81*** | 280.78*** |

Note: N=1,313. ***p<0.001; **p<0.01; *p<0.05

## 3.5 Discussions

This study investigates the role of CVC investment as a strategy for incumbent firms to create diversified technological options to prepare for future change. Specifically, I examined the effects of CVC investments into technologically capable venture companies on the corporate investors' technological diversity. I 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 empirical analysis help to support the hypotheses on the effects of CVC investments on the investor firms' technological diversification.

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, 2005a; Schildt et al., 2005; Maula et al., 2003; Wadhwa and Kotha, 2006; Van de Vrande et al., 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, 2005a; Wadhwa and Kotha, 2006). On the other hand, this study further analyzed the distribution of those patents among the different patent classes, allowing me 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 et al., 2007; Giuri et al., 2004; Mowery et al., 1998). Giuri et al. (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, Kale, Krishnan, and Singh, 2005; Helfat and Peteraf, 2003; Teece et al., 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 et al. (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, I regard CVC investments on technologically proficient start-up companies as explorative learning of incumbent firms and examine how the CVC investments contribute to securing various technological options and consequently improving their dynamic capabilities. In this study, multiple technological options are measured by analyzing the corporate investors' technological diversity after the CVC investments. This measure allows me 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, I 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. Additionally, 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.

# Chapter 4. Organizational Determinants of CVC Portfolio Diversification[5]

## 4.1 Introduction

Similar to strategic alliances and alliance portfolios, CVCs often do not only invest in a single company but assemble a portfolio of investments in several companies at the same time (Lin and Lee, 2011; Lee and Kang, 2015; Wadhwa, Phelps and Kotha, 2016; Yang, Chen and Zhang, 2016). This characteristic makes CVC especially suitable for diversified external search activities (Lavie, 2007; Yang, Narayanan, and De Carolis, 2014). By managing a diversified portfolio of different technology areas, corporate investors can access more diverse knowledge needed for innovation without receiving duplicated knowledge (Greve, 2007), and create more solutions by recombining various knowledge (Fleming, 2001). The diverse knowledge gained from diverse knowledge sources also enables the corporate investors to create various options that can be used in the future, thus enabling flexible responses of firms to unpredictable environmental changes (March 1991; Van de Vrande and Vanhaverbeke 2013). Specifically, since CVC investment requires a relatively smaller amount of equity investment than other external search strategies such as M&As and joint ventures, it is more suitable for diversified investments into emerging

[5] Chapter 4 is now under revision in *Journal of Business Venturing*

technology sectors with high uncertainties (Benson and Zieodonis 2009; Van de Vrande and Vanhaverbeke 2013). Many recent studies have empirically shown that corporate investors operating a diversified CVC portfolio benefit from a positive impact on firm value, growth rate, innovation performance, and technological diversification (Lin and Lee, 2011; Yang et al., 2014; Lee and Kang, 2015; Wadhwa et al., 2016).

However, despite the arguments of prior studies highlighting the strategic advantages of diversified CVC portfolios, in reality, some CVC investors possess a specialized portfolio focusing on a few specific technology areas rather than a diversified portfolio containing investments into various technology fields. I argue that the reason why some CVCs diversify their investment portfolio, while others do not, is the different managerial attention of corporate investors which can affect their strategic decision making when selecting investments targets (Maula et al., 2013; Yang et al., 2016). In other words, some corporate investors have the managerial attention to promote CVC portfolio diversification while others suppress it. Therefore, in order to understand how the level of CVC portfolio diversification is determined, a suitable approach is to analyze the factors affecting the managerial attention of the corporate investor.

In this study, based on a research question; “what are the organizational antecedents that determine the CVC portfolio diversity?”, I investigated three antecedent factors that can affect investment target selection: 1) the characteristics of the parent corporate investor involved in the final investment decisions, 2) the degree of organizational slack, and 3) the structural autonomy given to the managers of the CVC units (Siegel, Siegel, and MacMillan,

1988; Yang et al., 2016). In more detail, I first analyzed the role of the homogeneity of the CVC parent firm's top management team (TMT) members' backgrounds (educational, functional, and industrial experiences) and lack of organizational slack resources. I hypothesize that these factors limit CVC portfolio diversification. Next, I analyzed the impact of the CVC unit's structural autonomy which allows the managers dedicated to CVC investment to operate more autonomous investment portfolios by freeing them from the managerial attention of their parent corporate investors. The empirical analysis, based on 20 years of panel data from corporate investors in U.S. high-tech industries, statistically supports the hypotheses.

## 4.2 Research hypotheses

This chapter mainly focuses on the organizational characteristics of the firms which can affect the managerial attention of corporate investors. Better managerial implications can be obtained when considering corporate internal variables that can be strategically controlled, rather than studying external environmental variables that are difficult to influence. Therefore, I investigate the roles of three aspects of organizational characteristics: 1) the composition of the CVC parent firm's top management team, which can serve as the final decision maker in selecting the CVC investment targets, 2) the CVC parent firm's organizational slack resources that affect the setting of investment priorities, and 3) the degree of structural autonomy given to the CVC dedicated unit which allows the managers

who are dedicated to CVC portfolio management to find investment target more freely.

### 4.2.1 Top management team (TMT) homogeneity

Earlier studies on the upper-echelons perspective have suggested that the TMT plays an important role as the brain center of the organization and that the strategic effectiveness of the firm depends on the composition and characteristics of the TMT (Finkelstein and Hambrick 1996; Hambrick and Mason 1984). Specifically, some researchers suggested that the background, experience, and composition of TMT members play important roles in their strategic choices (Certo, Lester, Dalton, and Dalton, 2006; Sahaym, Cho, Kim and Mousa, 2016). For example, Bantel and Jackson (1989) suggested that demographically heterogeneous TMTs possess multiple strategic perspectives that are not available to more homogeneous TMTs. This TMT members' heterogeneity – the degree of diversity among executives' experience manifested in, e.g., their educational and functional background or tenure – also provides TMTs with valuable information from various knowledge areas (Williams and O'Reilly, 1998). These diverse strategic perspectives and improved information allow heterogeneous TMTs to avoid the groupthink frequently occurring in homogeneous TMTs, and result in more adventurous and future-oriented strategic choices (Certo et al., 2006; Hambrick and Mason, 1984). In contrast, firms led by low-diversity TMTs will exhibit relatively little strategic changes (Crossland, Zyung, Hiller, and Hambrick, 2014). These homogeneous TMTs also exhibit little temporal variation in their

business portfolio composition.

In particular, Cho and Hambrick (2006) extended the traditional upper-echelon perspective to the view of attentional orientations as a property of a TMT, or the strategic decision making unit of the organization. They argued that some attentional orientations will prevail in the TMT as a result of the collective experiences of the executives, and suggested that the TMT plays the role of the locus of managerial attention. Specifically, they suggested that TMT heterogeneity is related to the shift in managerial attention toward the entrepreneurial orientation of the firm. In other words, the diversity of the TMT members' backgrounds and experiences can determine the managerial attention which may affect the strategic decision making related to the entrepreneurial activities of the firm.

Recently, Sahaym et al. (2016) connected this concept of TMT heterogeneity and incumbent firms' CVC investment as an external searching activity. They used upper echelon and behavioral agency views and suggested that heterogeneous TMTs with diverse knowledge pools tend to avoid over-commitment to the status quo and are more open to using relatively new modes of growth such as CVC. In many cases, CVC parent firm's TMT members serve as the final decision makers in the CVC investment decision process (Gompers and Lerner, 2001). When a unit dedicated to CVC investment identifies candidates for investment target companies through the search process, the final investment council composed of TMT members decides whether or not to invest. Therefore, the managerial attention which determines the strategic objectives of CVC investments may depend on the characteristics and compositions of TMT members.

Specifically, in terms of CVC portfolio diversification, the heterogeneity or homogeneity of the TMT members mentioned in the preceding studies plays important roles in forming the managerial attention of the corporate investors. Heterogeneous TMT's members have different backgrounds in educational, functional, and industrial experiences, so they tend to have diverse professional fields and prefer to create a broader and more diverse knowledge base (Sahaym et al., 2016). This tendency leads heterogeneous TMTs to pursue more diversified portfolios in CVC investment. On the other hand, TMT's members who share homogeneous backgrounds and experiences have similar cognitive systems and strategic thinking (Duhaime and Schwenk, 1985; Prahalad and Bettis, 1986). This homogeneous thinking can be a factor that simplifies the strategic choice of the TMT and increases its inertia. Consequently, the homogeneous TMT tends to focus more on the current situation rather than on new changes or future growth, and prefers to construct a specific and deep searching portfolio on the common knowledge bases of its members. This tendency can be an organizational obstacle to assembling and operating a diversified CVC portfolio.

In summary, a homogeneous TMT is more likely to make specific investments in areas familiar to its members, rather than diversified investments in various fields. This tendency affects the industrial diversity when assembling a CVC investment portfolio. From this point of view, I present the following hypothesis:

***Hypothesis 4-1****: The corporate investor's TMT homogeneity has a negative relationship*

*with CVC portfolio diversification.*

### 4.2.2 Organizational slack resources constraints

Organizational slack or slack resources serve as a kind of buffer that can be employed towards a new strategic use in the future as an actual or potential resource that is not currently utilized (Bourgeois, 1981). Slack resources allow firms to afford to respond to competitive pressures, enable firms to experiment with strategic innovation, and perform various competitive moves (Cyert and March, 1963; Young, Smith, and Grimm, 1996). If the firm lacks slack resources, there is a constraint on the ability to procure the resources needed and the movement to pursue aggressive strategic changes (Ferrier, 2001; Fombrun and Ginsberg, 1990; Pettigrew, 1992; Young et al., 1996).

Previous studies on organizational slack resources suggest that slack is an important predictor of innovation, because firms with abundant slack possess more financial resources, valuable employees, and advanced technologies (Cyert and March, 1963; Thompson, 1967). Organizational slack provides a pool of resources that can ease adaptation to the flows of the innovation process (Nohria and Gulati, 1996). Moreover, slack resources also free the firm's managerial attention (Cyert and March, 1963). When a firm has fewer slack resources, managerial attention of the firm generally focuses on short-term performance issues. On the contrary, firms with abundant slack resources can place their managerial attention on more uncertain and innovative projects for long-term

performance (Nohria and Gulati, 1996). Recently, Lungeanu, Stern, and Zajac (2016) empirically showed that firms with less slack resources respond to poor innovative performance by down-scoping their technology sourcing portfolio and reverting to more familiar sourcing modes.

As an innovation strategy of external knowledge searching, CVC investments may also depend on the amount of slack resources. If the slack resources are sufficient, the corporate investors can make CVC investment in various companies and assemble a diversified industry portfolio. In other words, it is possible to afford enough resources to cover the risks that arise when operating diversified investment portfolios. On the other hand, if CVC investors do not have enough slack resources, they may have to reset their investment priorities and sometimes abandon new investment opportunities (Yang et al., 2014). Instead, preferential investment will be made to a few specific companies that have a relatively low investment risk and are expected to provide a faster return.

Therefore, corporate investors that have insufficient organizational slack resources may have a tendency to invest in a specialized portfolio for strategically prioritized sectors rather than construct diversified portfolios covering various technology fields. From this point of view, I present the following hypothesis:

***Hypothesis 4-2****: The corporate investor's lack of organizational slack resources has a negative relationship with CVC portfolio diversification.*

### 4.2.3 Structural autonomy of the CVC unit

The autonomy levels afforded to the CVC unit varies in different firms. Some CVC dedicated units are under tight control from the parent firm when selecting investment targets (Gompers and Lerner, 2001; Siegel et al., 1988). On the contrary, some other CVC units are wholly owned subsidiaries that operate completely free of the parent firms' interference. These differences in the structural autonomy levels of CVC units can lead to significant differences in attention allocation when assembling CVC portfolios.

Previous research suggested that CVC units will inevitably need to ignore their desire for short-term performance, and have to make investments that have value in their possibilities, which sometimes translates into a high-risk investment (Simon, Houghton, and Gurney, 1999). In order to make such adventurous and aggressive investment decisions, the CVC unit must operate independently of the parent company. Google Ventures and Intel Capital are typical examples of this concept of independent CVC. However, according to prior empirical analysis of the autonomy given to CVC units, traditionally, CVC units have been given a fairly limited autonomy, which has led to a lot of interference in their decision making (Brody and Ehrlich, 1998; Siegel et al., 1988).

For CVC unit which are tightly bound to their parent firm, their investment activity is performed according to the parent firm's strategic attention (Chesbrough, 2002). In this case, CVC units have a higher accountability to their parent firm and may interact with other business units in the firm (Birkinshaw and Hill, 2005). Therefore, it is difficult to

freely invest in the target companies that may cause conflicts with the interests of the parent firm, such as start-ups which could be potential competitors of the other business units. In addition, since the parent firm has the final decision-making power over the selection of CVC investment objects and the use of investment capital, investment in specific industries that can contribute to the existing firm's parent business model is intensified (Chesbrough, 2002; Siegel et al., 1988; Yang et al., 2016). Siegel et al., (1988) argued that these highly controlled CVC units may suffer from various organizational interferences such as their parent firm’s lack of a clear mission, lack of patience for long-term performance, lack of authority to make free decisions, and inadequate financial commitments.

On the other hand, CVC units, which have been granted the appropriate autonomy by combining the governance system of IVC, have the authority to independently make investment and management decisions. Autonomous governance allows operators of CVC units to better manage potential conflicts of interest between them and their parent firms (Burgelman, 1985; Dougherty, 1995). This type of CVC unit operates mostly in the form of a wholly owned subsidiary outside the parent firm and can make investment decisions independent of the current strategic attentions of the parent firm. Moreover, since these autonomous CVC units usually establish separate fund pools, they can be free from the restrictions of investment by the parent firms in insufficient resource situations (Birkinshaw and Hill, 2005). As a result, independent CVC units can pursue more adventurous and aggressive investment decision for long-term advantages, which leads to more variance performance in the long term.

The comparison of Google's and Cisco's cases shows that the CVC investment portfolio has different ways of operating according to the structural autonomy given to the CVC dedicated unit. As described in Chapter 3 above, Google has a highly diversified CVC investment portfolio. Google Ventures, a Google-owned subsidiary of CVC, is currently investing in diversified portfolio that includes Uber, a smartphone-based transportation service provider, Blue Bottle, an organic bean coffee company, Gritstone, a cancer immunotherapy vaccine provider analyzing patient information through AI technology, and Carbon, a company that develops 3D printing technology.

Since Google Ventures has been granted almost complete investment autonomy from Google, it can drive this highly diversified investment portfolio. Basically, Google Ventures has a responsibility to help the growth of its parent firm, Google. However, it is an independent organization that is guaranteed to be autonomous in both decision making and funding aspects of investment decisions. Google Ventures even makes a decision to sell the invested company, which has grown through CVC investment, to prime competitors of Google such as Facebook or Twitter. As such, Google Ventures is able to operate its diversified portfolio of investments from a longer-term perspective as it is free from the parent company's strategic interests and interferences.

On the other hand, Cisco, the leader in the network equipment market, is investing in CVC through an internal division called Cisco Corporate Development (CCD). The investment objective of CCD is not to search for various technological fields, but to search for M&A targets that have the necessary technology for parent company. When deciding

on CVC investments, Cisco prioritizes how well the technology and vision of the investee match Cisco. In addition, Cisco focuses on how quickly it can generate revenue through its newly acquired technological knowledge from portfolio companies.

In other words, because Cisco is making decisions about CVC investment within the enterprise organization, it will be subject to interference from other departments and tend to focus on short-term strategic gains rather than pursuing diversity from a long-term perspective. Looking at Cisco's recent investment portfolio, we can see that most of them are composed of big data, cloud computing, and IoT-related start-ups that can take advantage of Cisco's existing network technology.

In summary, since structurally autonomous CVC units can operate their investment portfolio freely and independent from their parent firms' strategic attentions, they can manage more diversified CVC portfolio aimed towards future long-term advantages. From this point of view, I present the following hypothesis:

***Hypothesis 4-3****: The level of structural autonomy of the CVC unit has a positive relationship with CVC portfolio diversification.*

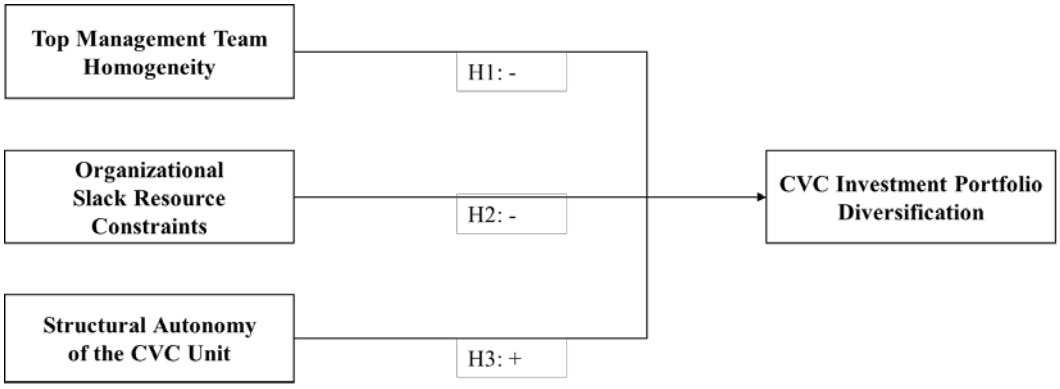


**Figure 4-1.** Conceptual Model for Chapter 4

The conceptual diagram in Figure 4-1 shows the relationships between the suggested hypotheses. Table 4-1 categorize the literatures of organizational factors that can affect to the operation of CVC portfolio.

**Table 4-1.** Literatures of organizational determinants of CVC investments

| Variable | Literatures | Interpretation |
|---|---|---|
| **Top Management Team Characteristics** | Finkelstein and Hambrick 1996; Hambrick and Mason 1984 | TMT plays an important role as the brain center of the organization<br>The strategic effectiveness of the firm depends on the composition and characteristics of the TMT |
| | Certo, Lester, Dalton, and Dalton, 2006 | The background, experience, and composition of TMT members play important roles in their strategic choices |
| | Bantel and Jackson, 1989; Williams and O'Reilly, 1998 | Demographically heterogeneous TMTs possess multiple strategic perspectives that are not available to more homogeneous TMTs |
| | Crossland, Zyung, Hiller, and Hambrick, 2014 | Low-diversity TMTs will exhibit relatively little strategic changes |
| | Cho and Hambrick, 2006 | Some attentional orientations will prevail in the TMT as a result of the collective experiences of the executives, and suggested that the TMT plays the role of the locus of managerial attention |
| | Sahaym, Cho, Kim and Mousa, 2016 | Heterogeneous TMTs with diverse knowledge pools tend to avoid over-commitment to the status quo and are more open to using relatively new modes of growth such as CVC. |
| **Organizational Slack** | Bourgeois, 1981 | Organizational slack or slack resources serve as a kind of buffer that can be employed towards a new strategic use in the future as an actual or potential resource that is not |

| | | |
|---|---|---|
| **Resources** | | currently utilized |
| | Cyert and March, 1963; Young, Smith, and Grimm, 1996 | Slack resources allow firms to afford to respond to competitive pressures, enable firms to experiment with strategic innovation, and perform various competitive moves |
| | Ferrier, 2001; Fombrun and Ginsberg, 1990; Pettigrew, 1992; Young et al., 1996 | Lack of slack resources cause the constraint on the ability to procure the resources needed and the movement to pursue aggressive strategic changes |
| | Nohria and Gulati, 1996 | Organizational slack provides a pool of resources that can ease adaptation to the flows of the innovation process |
| | Cyert and March, 1963 | Slack resources free the firm's managerial attention |
| | Lungeanu, Stern, and Zajac, 2016 | Firms with less slack resources respond to poor innovative performance by down-scoping their technology sourcing portfolio and reverting to more familiar sourcing modes |
| | Yang, Chen and Zhang, 2016 | Firms with less slack resources may have to reset their investment priorities and sometimes abandon new investment opportunities |
| **CVC Unit's Structural Autonomy** | Gompers and Lerner, 2001; Siegel et al., 1988 | Some CVC dedicated units are under tight control from the parent firm when selecting investment targets, and others are wholly owned subsidiaries that operate completely free of the parent firms' interference |
| | Simon, Houghton, and Gurney, 1999 | CVC units will inevitably need to ignore their desire for short-term performance, and have to make investments that have value in their possibilities, which sometimes translates into a high-risk investment |
| | Brody and Ehrlich, 1998 | CVC units have been given a fairly limited autonomy, which has led to a lot of interference in their decision making |
| | Chesbrough, 2002; Birkinshaw and Hill, 2005 | Tightly controlled CVC unit's investment activity is performed according to the parent firm's strategic attention |
| | Burgelman, 1985; Dougherty, 1995 | Autonomous governance allows operators of CVC units to better manage potential conflicts of interest between them and their parent firms |
| | Birkinshaw and Hill, 2005 | Autonomous CVC units with separate fund pools can be free from the restrictions of investment by the parent firms in insufficient resource situations |

## 4.3 Methods

### 4.3.1 Data and sample

This empirical analysis of this study was conducted on a sample of high-tech firms operating in the U.S., which have conducted CVC investments from 1990 to 2010. I believed that incumbent firms in high-tech industries are more likely to employ external knowledge sourcing through CVC investments because the technical paradigm shifts faster and the market uncertainty is higher in high-tech industries than in low-tech industries (Nelson and Winter, 1982; Teece, Pisano, and Shuen, 1997; Dushnitsky and Lenox, 2005; Gompers and Lerner, 2000).

I follow the classification of high-tech industries provided by the Securities Data Company (SDC) Platinum Database. According to this data, the following seven industries are classified as high-tech: ‘computer / IT’, ‘electrical & electronic / semiconductors’, ‘telecommunications / network’, ‘machinery / equipment’, ‘chemical / energy / material’, ‘biotechnology / pharmaceuticals / medical’, and ‘other technological services’. Furthermore, in order to collect the sample of investor firms, I used 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 me to collect investment round data to count the number of investments for each firm. Since many investor firms established subsidiaries or independent funds for their CVC investments, I resorted to searching by the name of subsidiaries and funds in online databases such as Lexis-Nexis DB to link them with their corporate parents.

I use Corporate Affiliations provided by LexisNexis and Who’s Who provided by

Marquis to collect TMT data. The TMT is defined as all executive level managers including the chief executive officer (CEO), chief technology manager (CTO), chief financial officer (CFO), chief strategy manager (CSO), Chief Operation Officer (COO), vice presidents, and other important managers (Finkelstein and Hambrick, 1996; Tabak and Barr, 1999; Kor, 2003). Text mining techniques were used to gather the necessary data from the biography of each TMT member. Their educational, functional, and industrial experience backgrounds were coded in classified categories. In total, I collected information on the background of 3,294 TMT members employed by 140 U.S. high-tech firms.

Moreover, to investigate the investor firms' technological diversity, I used patent class data provided by the U.S. Patents and Trademarks Office (USPTO) database. Last, other data such as the CVC parent firms' financial data and information on their M&A and alliance deals was gathered from the Compustat database provided by Standard and Poors and the Datastream database of Thomson Reuters. After gathering all variables and dropping samples that have missing data, I assembled a panel consisting of 455 firm-year observations of 69 sample firms.

### 4.3.2 Variables

#### 4.3.2.1 Dependent variable

The dependent variable of this study is *CVC Portfolio Diversification*, which shows how a focal firm spread its investments among start-ups from various technological fields.

The definition of this variable is based on industry diversification, because firms in the same industry are likely to possess similar technologies. The industries represented in the CVC investment portfolios are defined using two different industry coding schemes: the SIC (Standard Industrial Classification) code and the VEIC (Venture Economics Industry Classification) code. The SIC code has been extensively used to classify industries in many prior studies (Dushnitsky and Lenox, 2005; Keil, Maula, Schildt, and Zahra, 2008; Lin and Lee, 2011; Wadhwa et al., 2016). In recent years, also the VEIC code has also been employed by research on venture companies (Lee and Kang, 2015; Yang et al., 2016). I mainly use the 4-digit SIC code to measure *CVC Portfolio Diversification* but also perform an analysis using the 4-digit VEIC code as an additional robustness test.

Using these industry classifying codes and removing any duplicates, I counted the total number of industries invested in year t, and calculated the Herfindahl–Hirschman Index (HHI). The HHI has been widely used in prior literature which used industry diversification measures (Rumelt, 1974; Wernerfelt and Montgomery, 1988; Leten, Belderbos, and Van Looy, 2007; Yang et al. 2014). I used the following formula to calculate *CVC Portfolio Diversification*:

$$\mathrm{HHI} = (1 - \sum_{i=1}^{n} P_i^2)$$

where $P_i$ is the proportion of portfolio company from the i$^{th}$ industry within the total

number of portfolio companies. The HHI will have a value between 0 and 1, with a higher value showing a more diversified portfolio rather than a concentrated investment.

**Firm D's 2000**
**CVC Portfolio Diversification (SIC)**
$= \{1 - (\frac{1^2}{4} + \frac{1^2}{4} + \frac{1^2}{4} + \frac{1^2}{4})\} = 0.750$

**CVC Portfolio Diversification (VEIC)**
$= \{1 - (\frac{2^2}{4} + \frac{1^2}{4} + \frac{1^2}{4})\} = 0.625$

**Firm D's 2001**
**CVC Portfolio Diversification (SIC)**
$= \{1 - (\frac{2^2}{3} + \frac{1^2}{3})\} = 0.444$

**CVC Portfolio Diversification (VEIC)**
$= \{1 - (\frac{2^2}{3} + \frac{1^2}{3})\} = 0.444$

| CVC Firm | Portfolio Company | Year | Portfolio Company SIC | Portfolio Company VEIC |
|---|---|---|---|---|
| Firm D | Company A | 2000 | 5230 | 3841 |
| Firm D | Company B | 2000 | 2691 | 7375 |
| Firm D | Company C | 2000 | 2734 | 7372 |
| Firm D | Company D | 2000 | 3112 | 3841 |
| Firm D | Company B | 2001 | 2734 | 7372 |
| Firm D | Company D | 2001 | 5520 | 2834 |
| Firm D | Company E | 2001 | 2734 | 7372 |

**Figure 4-2.** CVC Portfolio Diversification Coding Example

#### 4.3.2.2 Independent variables

This study makes use of three independent variables. The first independent variable is the CVC parent firm's *TMT Homogeneity*. *TMT Homogeneity* was measured using the Herfindahl Index:

$$\mathrm{HI} = (\sum_{i=1}^{n} P_i^2)$$

where $P_i$ is the proportion of TMT members in each category of personal backgrounds (Blau, 1977; Carpenter Geletkanycz, and Sanders 2004; Certo et al., 2006; Finkelstein and

Hambrick, 1990; Pegels, Song, and Yang, 2000). The higher the HI, the more homogeneous is the TMT. I measured *TMT Homogeneity* in three dimensions, based on the educational, functional, and industrial experience backgrounds of the TMT members. I mainly use the educational background to measure *TMT Homogeneity*, with the other two measures serving as additional robustness tests. To measure these homogeneities, I grouped the individual backgrounds into several categories as follows: For TMT educational homogeneity, the categories were based on eleven major areas of study: 1) computer science, 2) electrical engineering, 3) mechanical engineering, 4) chemical engineering, 5) biotechnology / pharmaceuticals / medical, 6) other engineering and science, 7) economics, 8) business, 9) finance / accounting, 10) legal, and 11) other majors. To measure TMT functional homogeneity, TMT members were placed in one of the following seven functional categories: 1) R&D, 2) management, 3) finance/accounting, 4) operation, 5) marketing, 6) legal, and 7) other functions. Finally, for TMT industrial experience homogeneity, the categories are as follows: industry categories: 1) computer / IT, 2) electrical & electronic / semiconductors, 3) telecommunications / network, 4) machinery / equipment, 5) chemical / energy / material, 6) biotechnology / pharmaceuticals / medical, and 7) other industries.

| Firm Name | Manager Name | Age | Tenure | | Officer | | | Education Mojor | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Officer Start | Officer End | CEO | CTO | CFO | Computer Science | Electrical Engineering | Mechanic | Chemical | Bio / Pharma/ Medical | Other Engineering & Science | Economics | Accounting / Finance | Business | Legal | Other |
| Firm D | Manager 1 | 64 | 1990 | 2010 | 1 | | | | 1 | | | | | | | | | |
| Firm D | Manager 2 | 59 | 1991 | 2010 | | | 1 | | | | | | | 1 | | 1 | | |
| Firm D | Manager 3 | 43 | 2006 | 2010 | 1 | | | | | | 1 | | | | | 1 | | |
| Firm D | Manager 4 | 47 | 2007 | 2010 | | 1 | | | 1 | | | | 1 | | 1 | | | 1 |
| Firm D | Manager 5 | 51 | 2003 | 2010 | | | 1 | | | | | | | 1 | 1 | | | |
| Firm D | Manager 6 | 56 | 2003 | 2010 | | | 1 | | | | | | | | 1 | | 1 | |
| Firm D | Manager 7 | 70 | 1980 | 2010 | | | 1 | 1 | | | | | | | 1 | | | |
| Firm D | Manager 8 | 64 | 1980 | 2010 | | 1 | | | 1 | | | | 1 | | | | | |
| Firm D | Manager 9 | 61 | 1980 | 2010 | 1 | | | | 1 | | | | | | | | | |
| Firm D | Manager 10 | 48 | 2006 | 2010 | 1 | | | | | | | | | | 1 | 1 | | |
| Firm D | Manager 11 | 46 | 2006 | 2008 | 1 | | | 1 | 1 | | | | | | | 1 | | |
| Firm D | Manager 12 | 51 | 2005 | 2008 | 1 | | | 1 | | | | | | | | | | |
| Firm D | Manager 13 | 52 | 2004 | 2007 | | | | | | 1 | | | | | | | | |
| Firm D | Manager 14 | 50 | 2005 | 2007 | | 1 | | | 1 | | | | | | | | | |
| Firm D | Manager 15 | 47 | 2006 | 2006 | 1 | | | | | | | | | | | | | |
| Firm D | Manager 16 | 63 | 1998 | 2006 | 1 | | | | | | | | | | | | | 1 |
| Firm D | Manager 17 | 59 | 1999 | 2005 | 1 | | | | 1 | | | | | | | 1 | | |
| Firm D | Manager 18 | 56 | 2002 | 2004 | | | 1 | | | | | | | | 1 | | 1 | |
| Firm D | Manager 19 | 61 | 1999 | 2003 | 1 | | | 1 | | | | | | 1 | | | | |
| Firm D | Manager 20 | 62 | 1997 | 2002 | 1 | | | | | | | | | | 1 | 1 | | |
| Firm D | Manager 21 | 62 | 2000 | 2002 | | | 1 | | 1 | | | | | | | | | |
| Firm D | Manager 22 | 69 | 1990 | 2001 | | 1 | | | | | | | 1 | | | | | |
| Firm D | Manager 23 | 74 | 1985 | 2000 | | | 1 | 1 | | | | | | | | 1 | | |
| Firm D | Manager 24 | 70 | 1991 | 2000 | 1 | | 1 | 1 | | | | | | | | 1 | | |

**Figure 4-3.** TMT Educational Homogeneity Coding Example

The second independent variable is the CVC parent firm's *Organizational Slack Constraint*. Many organizational researchers have used the quick ratio and the current ratio to measure the organizational slack resource of the firm (Baucus and Near, 1991; Bergh, 1997; Herold, Jayaraman, and Narayanaswamy, 2006; Palmer and Wiseman, 1999). The quick ratio measures the ability of a firm to use its quick assets to retire its current liabilities. The current ratio is a very similar measure, but also considers the firms inventory and other current assets. Since these two ratios represent a firm's liquidity they are often used to measure the available organizational slack resources for innovative activities of a firm (Herold, Jayaraman, and Narayanaswamy, 2006). The quick ratio and current ratio are expressed as follows:

$$\text{Quick Ratio} = \frac{Cash\ and\ Cash\ Equivalent + Marketable\ Securities + Accounts\ Receivable}{Current\ Liabilities}$$

$$\text{Current Ratio} = \frac{Current\ Assets}{Current\ Liabilites}$$

Since I want to investigate the effects of insufficient slack resources, the reciprocals of the two ratios were used to measure a lack of slack condition.

The last independent variable is the *CVC Unit's Structural Autonomy*. While most prior research measured the structural autonomy of the CVC unit by using survey data (Birkinshaw and Hill, 2005; Hill and Birkinshaw, 2008), this study follows recent studies (Yang et al. (2016) and Kang and Park (2015, working paper) and bases its definition on

data collected from a database, in this case the ThomsonOne.com PE/VC Module database. Yang et al. (2016) classified CVC programs as either1) an internal program with direct investment from the parent corporate investor, or 2) a wholly owned independent subsidiary for CVC, which presents two different levels of structural autonomy. The authors argued that the managers of internal CVC program have less autonomy in their investment decision making because internalized investment tend to be closely aligned with the parent firm's strategic interests. On the other hand, a firm which operates a structurally independent subsidiary gives CVC managers a greater autonomy to manage the investment activities. In a similar manner, Kang and Park (2015) classified the structural form of CVC investments into three group based on information obtained from The Corporate Venturing Directory and Yearbook database: 1) structurally autonomous CVC unit, 2) direct investments by corporate investors, and 3) co-mingled pools managed by outside venture capital. Since the number of CVC units in group 3 (co-mingled pools) was too small, the authors excluded them from their analysis.

This study also follows Yang et al (2016) and Kang and Park (2015)'s approach to measure CVC unit's structural autonomy using a dummy variable. Each investment deal is classified as either a corporate investor's direct investment (autonomy value 0) or an investment of an independent CVC subsidiary (autonomy value 1). As a result, in this study, a corporate investor's annual CVC structural autonomy level is measured by the average value of each investment's structural autonomy which is distributed between 1 and 0.

Firm A's 2004
Average CVC Structural Autonomy
$= \frac{2\ (=number\ of\ autonomous\ investments)}{3\ (=total\ number\ of\ investments)} = 0.667$

Firm A's 2005
Average CVC Structural Autonomy
$= \frac{1\ (=number\ of\ autonomous\ investments)}{4\ (=total\ number\ of\ investments)} = 0.250$

| CVC Parent Firm Name | CVC Firm Name | Portfolio Company | Year | Structural Autonomy |
|---|---|---|---|---|
| A | A | Company 1 | 2004 | 0 |
| A | A Ventures | Company 2 | 2004 | 1 |
| A | A Ventures | Company 3 | 2004 | 1 |
| A | A | Company 4 | 2005 | 0 |
| A | A | Company 5 | 2005 | 0 |
| A | A | Company 6 | 2005 | 0 |
| A | A Ventures | Company 2 | 2005 | 1 |

**Figure 4-4.** CVC Unit's Structural Autonomy Coding Example

#### 4.3.2.3 Control variables

In addition to the three independent variables, there are other factors that can affect a corporate investor's CVC portfolio diversification, prompting me to add a number of control variables. First, a firm's size and R&D expenditures can affect the innovation and learning activities of firms. In general, larger firms have more resources to support CVC activities and thus find it easier to expand their CVC portfolio. The amount of R&D expenditure, on the other hand, reflects the engagement of a firm in innovative activities. Therefore, I included the natural log of firm i's total sales and the total R&D expenditure in year t-1 to create the control variables *Firm size* and *R&D expenditures*.

Secondly, I controlled for *Firm Age* and *TMT Average Age*. Prior research discovered that older firms tend to be conservative in their innovative activities (Hansen, 1992). This tendency is also found in the TMT. Hambrick and Mason (1984) suggested that older TMT members often avoiding to absorb unfamiliar technological change and are less inclined to

pursue risky strategies. Both variables were measured in the year t-1.

Next, I controlled for external knowledge sourcing activities by including the previous *M&A Experience* and *Alliance Experience* control variables. Since M&As and strategic alliances are other types of external knowledge sourcing strategies, their use can, both directly and indirectly, affect the firm's CVC investments. From the resource-based view, too much investment into M&As or alliance deals can hinder the overall CVC activities because of limited resources. From a different point of view, since abundant experiences with M&As or alliances could mean that the firm is familiar with external sourcing strategies, and thus might use CVC investments more actively. Therefore, I controlled for the total number of M&A and alliance deals in year t-1.

In addition, cumulative *Technology Stock*, and *Technology Diversity* also can impact the CVC portfolio diversification. These two variables have similar characteristics as M&A and alliance experiences. Abundant technology stock and technological diversity show that a firm invested a lot of resources to generate prior technological outputs. This could hint at insufficient resources for CVC investments. On the contrary, a firm with a rich technology stock and a diversified knowledge pool can find it easier to search for CVC investment targets from various technological field, increasing CVC portfolio diversification. Therefore, I controlled for the cumulated patent stock and patent class diversity in year t-1.

Finally, *Fixed Effects of Industry* is also an important variable that I need to control as different industries likely follow different trends 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. This could raise the possibility of firms in certain industries being more active in the pursuit of CVC investments. Therefore, I control for the fixed effects of the seven different industries by introducing dummy variables for each industry.

### 4.3.3 Statistical model

I used multivariate linear regression model to test linear positive relation between three independent variables (TMT Homogeneity, Lack of Organizational Slack Resources, and CVC Unit's Structural Autonomy) and CVC Portfolio Diversification. I then conducted Hausman test (Hausman, Hall, and Griliches 1984) to check whether a fixed-effects or random-effects model is more suitable for the dataset of this study. Following the outcome of the test, a random-effect model was used in the analysis.

**Table 4-2.** Variable descriptions

| Variables | Measures |
|---|---|
| CVC Portfolio Diversification | Herfindahl–Hirschman Index (HHI) using the proportion of portfolio companies in each category of industries |
| TMT Homogeneity (Education, Function, Industry) | Herfindahl Index (HI) using the proportion of TMT members in each category of personal backgrounds |
| Organizational Slack Constraint (Quick Ratio, Current Ratio) | Reciprocals of the quick & current ratios |
| CVC Unit's Structural Autonomy | Average value of each investment's structural autonomy (corporate investor's direct investment = 0, indirect investment through independent CVC unit = 1) |
| Firm Size | Natural log of total sales in last year |
| R&D Expenditure | Natural log of total R&D expenditure in last year |
| Firm Age | Firm age measured in last year |
| TMT Average Age | Average age of TMT members measured in last year |
| M&A Experience | Number of M&A deals in last year |
| Alliance Experience | Number of alliance deals in last year |
| Technology Stock | Cumulated patent stock in last year |
| Technology Diversity | Herfindahl–Hirschman Index (HHI) using the proportion of patents in each category of patent classes in last year |

## 4.4 Results

### 4.4.1 Descriptive statistics and correlations

Table 4-3 represents the descriptive statistics of all the variables used in this study and the correlations between them. The averages of the three categories of TMT homogeneity – educational, functional, and industry experience homogeneity – range from 0.291 to 0.393. In the sample, I can see TMT members' industrial experiences are more homogeneous than the managers' educational backgrounds and functional experiences. With regard to the structural autonomy of the CVC unit, about 57.3% of CVC deals were undertaken by structurally independent CVC units. Sample firms, on average, conducted 4.5 M&A deals and 6.5 alliance deals in year t-1. In the same period, they applied for 365.4 patents covering 38.2patent classes while they conducted on average 6.4 CVC deals.

**Table 4-3.** Descriptive statistics and correlations matrix of the variables

| | Variable | Mean | S.D. | Min | Max | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CVC Portfolio Diversification | 0.403 | 0.362 | 0 | 0.930 | 1.000 | | | | | | | | | | | | | | |
| 2 | TMT Homogeneity (Education) | 0.291 | 0.158 | 0.134 | 1 | -0.169 | 1.000 | | | | | | | | | | | | | |
| 3 | TMT Homogeneity (Function) | 0.306 | 0.128 | 0.160 | 1 | -0.123 | 0.397 | 1.000 | | | | | | | | | | | | |
| 4 | TMT Homogeneity (Industry) | 0.393 | 0.153 | 0.173 | 1 | -0.239 | 0.199 | 0.122 | 1.000 | | | | | | | | | | | |
| 5 | Org. Slack Constraint (Quick Ratio) | 0.814 | 0.457 | 0.067 | 3.030 | -0.049 | 0.123 | 0.214 | -0.111 | 1.000 | | | | | | | | | | |
| 6 | Org. Slack Constraint (Current Ratio) | 0.600 | 0.299 | 0.065 | 1.887 | -0.030 | 0.073 | 0.150 | -0.162 | 0.917 | 1.000 | | | | | | | | | |
| 7 | CVC Unit's Structural Autonomy | 0.573 | 0.482 | 0 | 1 | 0.250 | 0.014 | 0.127 | -0.099 | 0.036 | 0.049 | 1.000 | | | | | | | | |
| 8 | Firm Size | 9.205 | 1.836 | 2.060 | 12.449 | 0.254 | 0.004 | 0.121 | -0.281 | 0.470 | 0.482 | 0.266 | 1.000 | | | | | | | |
| 9 | R&D Expenditure | 6.768 | 1.512 | 2.428 | 9.408 | 0.273 | -0.066 | -0.098 | -0.259 | 0.128 | 0.129 | 0.118 | 0.735 | 1.000 | | | | | | |
| 10 | Firm Age | 55.138 | 47.687 | 1 | 174 | 0.043 | -0.014 | 0.205 | -0.164 | 0.427 | 0.334 | 0.215 | 0.522 | 0.359 | 1.000 | | | | | |
| 11 | TMT Average Age | 47.502 | 4.335 | 35.8 | 58.944 | 0.028 | 0.085 | 0.239 | -0.044 | 0.261 | 0.239 | 0.162 | 0.329 | 0.261 | 0.328 | 1.000 | | | | |
| 12 | M&A Experience | 4.475 | 5.271 | 0 | 44 | 0.261 | 0.069 | -0.095 | -0.240 | 0.030 | 0.057 | -0.062 | 0.315 | 0.358 | 0.013 | -0.083 | 1.000 | | | |
| 13 | Alliance Experience | 6.488 | 12.024 | 0 | 97 | 0.188 | 0.051 | -0.028 | -0.175 | -0.082 | -0.054 | -0.120 | 0.218 | 0.306 | -0.023 | -0.231 | 0.595 | 1.000 | | |
| 14 | Technology Stock | 365.382 | 591.825 | 0 | 3684 | 0.086 | 0.053 | 0.066 | -0.190 | 0.126 | 0.139 | 0.090 | 0.429 | 0.490 | 0.287 | 0.158 | 0.254 | 0.282 | 1.000 | |
| 15 | Technology Diversity | 0.722 | 0.294 | 0 | 0.985 | 0.027 | 0.182 | -0.033 | -0.138 | -0.023 | -0.035 | 0.115 | 0.250 | 0.332 | 0.193 | 0.114 | 0.198 | 0.141 | 0.416 | 1.000 |

Note: N=455. Dummy variables were excluded.

### 4.4.2 Regression results

Table 4-4 shows the results of the random effects GLS regression model. Model 1 is the unconstrained model which only includes the control variables. The coefficient for Alliance Experiences is significant, i.e., I find that firms with more alliance experience tend to assemble more diverse CVC portfolios. Model 2, 3, and 4 additionally include TMT Homogeneity (calculated based on the TMT members' educational backgrounds), Organizational Slack Constraint (quick ratio), and the CVC Unit's Structural Autonomy to test Hypotheses 1, 2, and 3. Last, Model 5 is the full model that includes all variables.

Hypothesis 1 predicts a negative relationship between the TMT homogeneity of the parent firm and CVC portfolio diversification. I argue that as the parent firm has more homogeneous TMT members, it places similar strategic attention on the target technological fields of CVC investments, and thus the diversity of the CVC portfolio will decrease. In Model 2, I find a negative and statistically significant coefficient of TMT Homogeneity ($b=-0.404, p<0.001$). This result supports Hypothesis 1.

Hypothesis 2 predicts that scarce organizational slack resources are negatively related to CVC portfolio diversification. I argue that parent firms suffering from a shortage of slack resource prioritize CVC investment targets with relatively low uncertainty, resulting in a decrease of the diversity the CVC portfolio. In Model 3, the coefficient of Organizational Slack Constraint is negative and statistically significant ($b=-0.155, p<0.01$), which is consistent with Hypothesis 2.

Model 4 identifies the effects of the CVC Unit's Structural Autonomy on CVC portfolio diversification. I argue that a higher level of structural autonomy of the CVC unit can increase the diversity of the CVC portfolio (Hypothesis 3). In Model 4, I find a positive and statistically significant coefficient of CVC Unit's Structural Autonomy (b=-0.157,$p<0.001$), which is consistent with Hypothesis 3.

The full model of this research is shown in Model 5. It includes all independent and control variables. I can find that the coefficients of all three independent variables are statistically significant and that their directions support the corresponding hypotheses (TMT Homogeneity: b=-0.363,$p<0.01$, Organizational Slack Constraint: b=-0.104,$p<0.05$, CVC Unit's Structural Autonomy: b=0.150,$p<0.001$). Moreover, I can see that the values of overall $R^2$ and Wald $\chi^2$ increase when a new independent variable is added to the model. In particular, the overall $R^2$ and Wald $\chi^2$ of Model 5, which is the full model, were the highest at 0.200 and 85.87 ($p<0.001$). This means that three independent variables of this study can statistically explain the change in the level of CVC portfolio diversification.

**Table 4-4.** Regression results (GLS Regression Models using TMT Educational Homogeneity and Quick Ratio as Independent Variable)

| ***Dependent Variable*** (CVC Portfolio Diversification) | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** |
|---|---|---|---|---|---|
| ***Control Variables*** | | | | | |
| Firm Size | 0.029<br>(0.020) | 0.033+<br>(0.019) | 0.0508*<br>(0.021) | 0.015<br>(0.019) | 0.034+<br>(0.020) |
| R&D Expenditure | 0.035<br>(0.022) | 0.023<br>(0.022) | 0.022<br>(0.023) | 0.044*<br>(0.021) | 0.024<br>(0.021) |
| Firm Age | -0.001<br>(0.001) | -0.001<br>(0.001) | -0.001<br>(0.001) | -0.001+<br>(0.001) | -0.001<br>(0.001) |
| TMT Average Age | -0.001<br>(0.005) | 0.000<br>(0.005) | -0.002<br>(0.005) | -0.001<br>(0.005) | 0.000<br>(0.005) |
| M&A Experience | 0.005<br>(0.004) | 0.005<br>(0.004) | 0.005<br>(0.004) | 0.006<br>(0.004) | 0.007+<br>(0.004) |
| Alliance Experience | 0.007***<br>(0.002) | 0.007***<br>(0.002) | 0.007***<br>(0.002) | 0.007***<br>(0.002) | 0.007***<br>(0.002) |
| Technology Stock | 0.000<br>(0.000) | 0.000<br>(0.000) | 0.000<br>(0.000) | 0.000<br>(0.000) | 0.000<br>(0.000) |
| Technology Diversity | -0.054<br>(0.068) | -0.031<br>(0.068) | -0.073<br>(0.068) | -0.068<br>(0.067) | -0.058<br>(0.066) |
| Industry Dummies | Included | Included | Included | Included | Included |
| _Cons | -0.116<br>(0.237) | -0.012<br>(0.233) | -0.008<br>(0.235) | -0.112<br>(0.227) | -0.019<br>(0.222) |
| ***Independent Variables*** | | | | | |
| TMT Homogeneity<br>(Educational Backgrounds) | | -0.404***<br>(0.114) | | | -0.363**<br>(0.112) |
| Organizational Slack Constraint<br>(Quick Ratio) | | | -0.155**<br>(0.048) | | -0.104*<br>(0.047) |
| CVC Unit's Structural Autonomy | | | | 0.157***<br>(0.043) | 0.150***<br>(0.043) |
| Observations | 452 | 451 | 452 | 452 | 451 |
| Overall $R^2$ | 0.105 | 0.129 | 0.123 | 0.170 | 0.200 |
| Wald $\chi^2$ | 49.25*** | 62.85*** | 60.70*** | 64.12*** | 85.87*** |

Note: N=455. ***p<0.001; **p<0.01; *p<0.05; + p < 0.10

### 4.4.3 Robustness tests

#### 4.4.3.1 Alternative measures of the independent variables

I conducted additional robustness tests using other measures of two independent variables, TMT Homogeneity and Organizational Slack Constraint, to verify the consistency of statistical results. First, I employed two other dimensions of TMT members' backgrounds, i.e., their functional experiences and industry experiences. Model 6 in Table 4-5 identifies the effects of TMT members' functional homogeneity on CVC portfolio diversification. I find that TMT functional homogeneity has a negative and statistically significant relationship with CVC portfolio diversification ($b=-0.274, p<0.10$). In Model 7, TMT industry experience homogeneity, another dimension of TMT homogeneity, also has a negative and statistically significant coefficient (($b=-0.277, p<0.05$). These results are consistent with Hypothesis 1.

I also conducted a regression analysis in which I measured the Organizational Slack Constraint using the current ratio. The results of this analysis are shown in Model 8 of Table 3. I find that the coefficient is negative and statistically significant ($b=-0.254$, $p<0.001$), which is consistent with Hypothesis 2.

The full models with the alternative measures of the two independent variables and the CVC Unit's Structural Autonomy are shown in Models 9, 10, 11, 12, and 13. Also in these full models all the coefficients of the independent variables are consistently supporting the hypotheses.

#### 4.4.3.2 Alternative measures of the dependent variable

Additionally, I performed regression analysis using other measure for the dependent variable. As I explained above, the VEIC code can be used to create an alternative measurement of CVC Portfolio Diversification. Table 4-6 shows the full results of the additional regression analysis in which CVC Portfolio Diversification was calculated using the 4-digit VEIC code. I find that all the coefficients of the independent variables are statistically significant and have the same directions as the original results using the 4-digit SIC code. This finding shows that the hypotheses are consistently supported also when using an alternative industry classification and further increases the robustness of empirical results.

**Table 4-5.** Robustness test (GLS regression models using alternative measures of independent variables)

| Variables | Model 1 | Model 2 | Model 6 | Model 7 | Model 3 | Model 8 | Model 4 | Model 5 | Model 9 | Model 10 | Model 11 | Model 12 | Model 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Control Variables*** | | | | | | | | | | | | | |
| Firm Size | 0.029 | 0.033 | 0.034 | 0.023 | 0.051* | 0.054* | 0.015 | 0.034+ | 0.039+ | 0.030 | 0.038+ | 0.042* | 0.033 |
| | (0.020) | (0.019) | (0.020) | (0.019) | (0.021) | (0.021) | (0.019) | (0.020) | (0.020) | (0.020) | (0.020) | (0.020) | (0.020) |
| R&D Expenditure | 0.035 | 0.023 | 0.025 | 0.035 | 0.022 | 0.022 | 0.044* | 0.024 | 0.022 | 0.032 | 0.022 | 0.020 | 0.031 |
| | (0.022) | (0.022) | (0.023) | (0.022) | (0.023) | (0.023) | (0.021) | (0.021) | (0.022) | (0.021) | (0.021) | (0.022) | (0.021) |
| Firm Age | -0.001 | -0.001 | -0.001 | -0.001+ | -0.001 | -0.001 | -0.001+ | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001+ |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| TMT Average Age | -0.001 | 0.000 | 0.000 | 0.000 | -0.002 | -0.001 | -0.001 | 0.000 | -0.001 | -0.001 | 0.000 | 0.000 | 0.000 |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| M&A Experience | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.006 | 0.006 | 0.007+ | 0.006+ | 0.006+ | 0.007+ | 0.006+ | 0.006+ |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| Alliance Experience | 0.007*** | 0.007*** | 0.007*** | 0.007*** | 0.007*** | 0.007*** | 0.007*** | 0.007*** | 0.007*** | 0.006*** | 0.007*** | 0.007*** | 0.006*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| Technology Stock | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Technology Diversity | -0.054 | -0.031 | -0.055 | -0.054 | -0.073 | -0.075 | -0.068 | -0.058 | -0.085 | -0.085 | -0.060 | -0.088 | -0.087 |
| | (0.068) | (0.068) | (0.068) | (0.068) | (0.068) | (0.068) | (0.067) | (0.066) | (0.066) | (0.066) | (0.066) | (0.067) | (0.066) |
| Industry Dummies | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included |
| _Cons | -0.116 | -0.012 | -0.047 | 0.005 | -0.088 | -0.086 | -0.112 | -0.019 | -0.039 | 0.030 | -0.012 | -0.030 | 0.042 |
| | (0.237) | (0.233) | (0.239) | (0.240) | (0.235) | (0.236) | (0.227) | (0.222) | (0.227) | (0.229) | (0.222) | (0.227) | (0.229) |
| ***Independent Variables*** | | | | | | | | | | | | | |
| TMT Homogeneity 1 (Educational Backgrounds) | | -0.404*** | | | | | | -0.363** | | | -0.380*** | | |
| | | (0.114) | | | | | | (0.112) | | | (0.111) | | |
| TMT Homogeneity 2 (Functional Experiences) | | | -0.274+ | | | | | | -0.286+ | | | -0.312* | |
| | | | (0.159) | | | | | | (0.152) | | | (0.151) | |
| TMT Homogeneity 3 (Industry Experiences) | | | | -0.277* | | | | | | -0.294* | | | -0.316* |
| | | | | (0.140) | | | | | | (0.133) | | | (0.133) |
| Organizational Slack Constraint 1 (Quick Ratio) | | | | | -0.155** | | | -0.104* | -0.126** | -0.132** | | | |
| | | | | | (0.048) | | | (0.047) | (0.047) | (0.047) | | | |
| Organizational Slack Constraint 2 (Current Ratio) | | | | | | -0.254*** | | | | | -0.180* | -0.208** | -0.217** |
| | | | | | | (0.077) | | | | | (0.074) | (0.075) | (0.074) |
| CVC Unit's Structural Autonomy | | | | | | | 0.157*** | 0.150*** | 0.151*** | 0.145*** | 0.149*** | 0.150*** | 0.143*** |
| | | | | | | | (0.043) | (0.043) | (0.043) | (0.043) | (0.043) | (0.043) | (0.043) |
| Observations | 452 | 451 | 452 | 452 | 452 | 452 | 452 | 451 | 452 | 452 | 451 | 452 | 452 |
| Overall $R^2$ | 0.105 | 0.129 | 0.114 | 0.128 | 0.123 | 0.119 | 0.170 | 0.200 | 0.190 | 0.203 | 0.199 | 0.188 | 0.201 |
| Wald $\chi^2$ | 49.25*** | 62.85*** | 52.44*** | 53.57*** | 60.70*** | 61.18*** | 64.12*** | 85.87*** | 77.13*** | 79.62*** | 86.92*** | 77.57*** | 79.99*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |

Note: N=455. ***p<0.001; **p<0.01; *p<0.05; + p < 0.10

**Table 4-6.** Robustness test (GLS regression models using alternative measures of dependent variables - VEIC)

| Variables | Model 1 | Model 2 | Model 6 | Model 7 | Model 3 | Model 8 | Model 4 | Model 5 | Model 9 | Model 10 | Model 11 | Model 12 | Model 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Control Variables*** | | | | | | | | | | | | | |
| Firm Size | 0.036+ | 0.040+ | 0.040+ | 0.028 | 0.061** | 0.062** | 0.020 | 0.043* | 0.047* | 0.036 | 0.045* | 0.049* | 0.037 |
| | (0.021) | (0.020) | (0.021) | (0.020) | (0.022) | (0.022) | (0.020) | (0.021) | (0.021) | (0.020) | (0.021) | (0.021) | (0.021) |
| R&D Expenditure | 0.033 | 0.022 | 0.023 | 0.033 | 0.018 | 0.018 | 0.044* | 0.022 | 0.020 | 0.029 | 0.021 | 0.019 | 0.029 |
| | (0.023) | (0.023) | (0.024) | (0.023) | (0.024) | (0.024) | (0.022) | (0.022) | (0.023) | (0.022) | (0.022) | (0.023) | (0.022) |
| Firm Age | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001+ | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| TMT Average Age | 0.000 | 0.001 | 0.001 | 0.002 | -0.001 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| M&A Experience | 0.005 | 0.005 | 0.005 | 0.005 | 0.006 | 0.006 | 0.006+ | 0.007 | 0.007+ | 0.007+ | 0.007+ | 0.007+ | 0.007+ |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| Alliance Experience | 0.007*** | 0.008*** | 0.008*** | 0.007*** | 0.007*** | 0.007*** | 0.007*** | 0.007*** | 0.007*** | 0.006** | 0.007*** | 0.007*** | 0.006** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| Technology Stock | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Technology Diversity | -0.071 | -0.052 | -0.072 | -0.071 | -0.094 | -0.094 | -0.085 | -0.083 | -0.105 | -0.104 | -0.083 | -0.106 | -0.106 |
| | (0.072) | (0.071) | (0.071) | (0.071) | (0.071) | (0.071) | (0.070) | (0.069) | (0.069) | (0.068) | (0.069) | (0.069) | (0.069) |
| Industry Dummies | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included | Included |
| _Cons | -0.175 | -0.078 | -0.110 | -0.022 | -0.141 | -0.142 | -0.171 | -0.084 | -0.100 | 0.006 | -0.077 | -0.092 | 0.018 |
| | (0.248) | (0.246) | (0.251) | (0.250) | (0.246) | (0.247) | (0.236) | (0.233) | (0.237) | (0.236) | (0.233) | (0.237) | (0.237) |
| ***Independent Variables*** | | | | | | | | | | | | | |
| TMT Homogeneity 1 (Educational Backgrounds) | | -0.352** | | | | | | -0.300* | | | -0.326** | | |
| | | (0.120) | | | | | | (0.117) | | | (0.116) | | |
| TMT Homogeneity 2 (Functional Experiences) | | | -0.256 | | | | | | -0.264+ | | | -0.296+ | |
| | | | (0.167) | | | | | | (0.159) | | | (0.158) | |
| TMT Homogeneity 3 (Industry Experiences) | | | | -0.354* | | | | | | -0.370** | | | -0.394** |
| | | | | (0.146) | | | | | | (0.137) | | | (0.137) |
| Organizational Slack Constraint 1 (Quick Ratio) | | | | | -0.183*** | | | -0.132** | -0.151** | -0.155** | | | |
| | | | | | (0.050) | | | (0.049) | (0.049) | (0.048) | | | |
| Organizational Slack Constraint 2 (Current Ratio) | | | | | | -0.272*** | | | | | -0.196* | -0.221** | -0.230** |
| | | | | | | (0.081) | | | | | (0.078) | (0.078) | (0.077) |
| CVC Unit's Structural Autonomy | | | | | | | 0.177*** | 0.167*** | 0.166*** | 0.163*** | 0.168*** | 0.168*** | 0.163*** |
| | | | | | | | (0.045) | (0.045) | (0.045) | (0.044) | (0.045) | (0.045) | (0.044) |
| Observations | 452 | 451 | 452 | 452 | 452 | 452 | 452 | 451 | 452 | 452 | 451 | 452 | 452 |
| Overall $R^2$ | 0.108 | 0.125 | 0.115 | 0.139 | 0.130 | 0.123 | 0.183 | 0.207 | 0.201 | 0.224 | 0.205 | 0.198 | 0.221 |
| Wald $\chi^2$ | 48.89*** | 58.07*** | 51.37*** | 55.57*** | 63.54*** | 61.36*** | 66.77*** | 86.25*** | 80.94*** | 88.13*** | 85.34*** | 79.31*** | 86.61*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |

Note: N=455. ***p<0.001; **p<0.01; *p<0.05; + p < 0.10

## 4.5 Discussions

This study investigates the roles of TMT configuration, organizational slack resources, and structural autonomy of the CVC unit as antecedent factors which determine the level of CVC portfolio diversification. Specifically, I examined the effects of TMT members' educational, functional, and industry experience homogeneities and the lack of organizational slack resources of the firm as organizational obstacles which suppress their CVC portfolio diversity. I also examined the role of the CVC unit's structural autonomy as a catalyst to increase CVC portfolio diversification by decreasing the organizational interference of the parent firm's strategic attention. I analyzed empirical data of U.S. high-tech firms that have participated in CVC investments between 1990 and 2010. All results of empirical analysis support the hypotheses on the effect of the three organizational antecedent factors on the CVC investment portfolio diversification.

This study contributes to several strands of literature: First, this study offers an empirical perspective on evaluating the impacts of organizational determinants that can affect the level of CVC portfolio diversification. While previous literature has acknowledged the importance of diversified portfolio management in CVC investment, most related studies tend to focus on the effects of CVC portfolio diversity on the corporate investor's financial and technological performance (Lin and Lee, 2011; Yang et al., 2014; Lee and Kang, 2015; Wadhwa et al., 2016). Unlike this previous research, this study focuses on the role of organizational antecedents that can stimulate or suppress CVC portfolio

diversification, allowing me to understand the strategic decision making mechanisms involved in selecting investment target companies and their technological fields.

Second, this study also contributes to the development of the managerial attention literatures by focusing on the mediation role of managerial attention that links the organizational characteristics of corporate investors and their decision-making process for deciding on CVC investment targets (Ocasio, 1997; Simon, 1947).This is the second study linking the managerial attention concept and CVC portfolio diversification after Yang et al. (2016). While Yang (2016) focuses only on the role of CVC autonomy, this study additionally presents TMT homogeneity and organizational slack resource constraints as other organizational variables that may influence the process of determining investment targets. TMT members' personal experience backgrounds are important organizational characteristics that represent the managerial attention of the final decision makers who select CVC investment targets. If TMT members share excessively similar experiences, their managerial attentions and strategic perspectives on external sourcing through CVC investments may be very similar. This similarity impedes CVC portfolio diversification. In addition, if a corporate investor does not possess sufficient organizational slack resources, its managerial attention will be placed on investing in specific technology areas that are directly related to its current business model instead of diversified investments in various technology areas. However, if departments dedicated to CVC investment are free to operate from the parent firm's strategic attentions, they will be able to pursue more variance performance in the long term instead of short term mean performance (Yang et al., 2016).

Finally, the analytic findings of this study provide managerial implications on how corporate investors operate their CVC portfolios. Many prior studies suggested that CVC activities should be established as an independent unit and should have access to a committed, separate pool of funds, because independent CVCs are able to respond aggressively to, and manage, various investment opportunities with minimal corporate interference (Gompers and Lerner, 2001; Siegel et al., 1988). On the other hand, if the CVC investment is strongly controlled by the parent firm, it will have an investment orientation that is tailored to the strategic perspective and resource context of the parent firm. This makes it very difficult to conduct diversified investments from a long-term perspective. In this respect, this study provides some hints on the organizational structure needed to operate a diversified CVC portfolio.

# Chapter 5. Exploration and Exploitation through CVC Investments[6]

## 5.1 Introduction

In terms of innovation strategy, CVC investment is characterized by pursuing both of exploration and exploitation (Galloway, Miller, Sahaym, and Arthurs, 2017; Hill and Birkinshaw, 2014): where exploration is to search and acquire unfamiliar and novel technologies and resources which aims to generate variation, while exploitation focuses mainly on the enhancement of the efficiency and productivity of firm' activities through refinement and extension of existing competencies and technologies. Indeed, NIST's (National Institute of Standards and Technology) survey[7] of CVC investors supported this argument. According to the survey results, many respondents selected both choices which includes "providing window on new technology" and "supporting existing business" as the most important strategic objectives of their CVC investments.

Several studies based on survey or case study have discussed about the exploitative learning activities through CVC investments (Battistini et al., 2013; Markham et al., 2005). However, most of the previous studies which empirically analyzed the effect of CVC

[6] Chapter 5 is now under revision in *Journal of Business Research*

[7] MacMillan I., Roberts E., Livada V., and Wang A. (2008). Corporate venture capital (CVC): seeking innovation and strategic growth. *Supported by National Institute of Science and Technology (NIST)*

investment on an investor firm's innovation performance have focused only on the impact of CVC investment on the explorative innovation, which is manifested in such specific purposes as providing window on new technology and seeking new business opportunities (Basu and Phelps, 2009; Burgelman, 1983; Dushnitsky and Lenox, 2006; Kanter, 1985; Wadhwa and Kotha, 2006). In contrast to this academic tendency, Hill and Birkinshaw (2014) argued that the overall CVC success rate is relatively low because many CVC programs are frequently seen as too exploratory, investing in target companies which are too far from the firm's core business or having extreme difficulties in integrating it into its existing operations (Burgelman and Valïkangas, 2005; Chesbrough, 2000; Gompers and Lerner, 1998). In other words, in order to achieve a successful investment performance, corporate investors should implement ambidextrous strategy of the investment for exploitation in parallel with the investment for exploration.

In this vein, in order to fill the gap between the survey results of practitioners and the flow of empirical research in academia, I raised a research question; "how the level of the structural autonomy given to the CVC dedicated unit and investor firm's internal technological diversity affect the two different kinds of innovation; exploration and exploitation?", and empirically analyzed this issue. At the first, from an organizational standpoint, I focused on the structural autonomy of CVC unit, which has a significant impact on the operating process of CVC investment (Gompers and Lerner, 2001; Siegel, Siegel, and MacMillan, 1988; Yang, Chen, and Zhang, 2016). CVC unit's structural autonomy allows the managers to be dedicated in CVC investments while operating in

more autonomous investments by freeing themselves from the strategic attention of their parent firm (Yang, Chen, and Zhang, 2016). Since autonomous CVC unit tends to respond aggressively to investment in different opportunities with minimal corporate interferences, it can operate more as a diversified portfolio and take more risks in adventurous investments in unfamiliar technology areas (Siegel et al., 1988). GV (formerly Google Ventures), a completely separated subsidiary of Google, is a typical example of such autonomous CVC. Due to this specificity of investment process, I argue that structural autonomy will have different impacts on explorative and exploitative innovation through CVC investments. The autonomous CVC's free investment activities and diverse portfolio can be helpful for exploring new technology areas. On the other hand, in exploitation to enhance the existing business of the parent company, autonomous CVCs may have a negative impact, as they are disconnected from the expertise of the parent company and accumulated technological knowledge and network resources. Therefore, I hypothesize that the degree of structural autonomy on CVC unit may increase the corporate investor's explorative innovation performance, while it may decrease exploitative innovation performance.

In addition, from the perspective of the knowledge resources that a corporate investor has, I have also examined the impact of the investor firm's technological diversity on the innovation performance that is created through CVC investments. A firm's existing technological knowledge is combined with newly acquired knowledge to create a new recombination and application (Keil, 2004). In particular, if a firm has several pieces of

knowledge that are unconnected, acquiring new knowledge to recombine them can create more innovative synergies (Wadhwa and Kotha, 2006). Moreover, in many cases, the heterogeneity or diversity of firm's technological knowledge base increases the firm's absorptive capacity (March 1991; Tushman and O'Reilly 1996). Therefore, firms that already have knowledge in various technological fields are more likely to create new innovations by better understanding and utilizing technologies acquired through CVC. In this vein, I hypothesize that the degree of corporate investor's technological diversity may increase the corporate investor's explorative and exploitative innovation performance.

Empirically, I analyzed an unbalanced panel of U.S. high-tech firms that have experiences in CVC investment during the time period of 1990 to 2010. As a result of empirical analysis, I find that increases in the degree of structural autonomy on CVC unit are associated with subsequent increases in number of newly applied patents and their forward citations in explorative technology area, while it is negatively related with the number of applied patents and forward citations in exploitative technology area. In addition, I also find that the corporate investor's knowledge diversity is positively related with both of subsequent exploration and exploitation performance through CVC investments.

## 5.2 Research hypotheses

### 5.2.1 Exploration and exploitation through CVC investments

In general, studies on CVC investment consider the CVC unit as a separated department for explorative learning. Although this study regard CVC unit as a separated department for incumbent firm's external searching activity, I argue that the CVC unit's activities are not only limited to exploration but also conducts exploitative learning activities (Campbell, Birkinshaw, Morrison, and van Basten Batenburg, 2003; Hill and Birkinshaw, 2008, 2014; Keil, Maula, Schildt, and Zahra, 2008, Schildt, Maula, and Keil, 2005). In reality, many CVC investors who have exploitative strategic objectives are investing in start-ups with relevant knowledge and skills to enhance their current business model. For example, Intel, a worldwide developer of microprocessor, manage diversified investment portfolios with the start-ups in unrelated industry area to prepare future change, but it is also investing heavily in startups in related industries to improve the performance of their core business, microprocessor, through their CVC subsidiary, Intel Capital. Thus, in order to better understand innovation strategy through CVC investment, it is necessary to analyze both the explorative and exploitative nature of CVC. In particular, this study examines the organizational ambidexterity in terms of the operation of the CVC dedicated unit because the direction of innovation acquired by CVC investment may depend on how incumbent firm operate CVC structurally. Among the various elements of CVC operation, the notable element in this study is the autonomy that is given to the CVC dedicated unit.

### 5.2.2 Structural autonomy of CVC unit and exploration

For corporate investors, one of the main issues in operating CVC is how much autonomy should be given to the CVC dedicated unit. Some CVC units receive tight control from the parent firm in selecting investment targets, while some other CVC units are wholly owned subsidiaries that operate completely independent from the parent firm's control (Gompers and Lerner, 2001; Siegel et al., 1988).

Currently, many previous studies have suggested that CVC units should be given more autonomy to improve the strategic performance of CVC investment. They suggested that CVC units will inevitably need to ignore their desire for short-term performance while having to make investments that have future value within boundaries of the different possibilities (or opportunities), and making high-risk investments time to time. (Simon, Houghton, and Gurney, 1999). In order to pursue such adventurous and aggressive investment decision, the CVC unit must operate independently of the parent firm.

CVC unit, which has been granted the appropriate autonomy by combining the governance system of IVC, has the authority to independently make investment and management decisions. Autonomous governance allows operators of CVC unit to better manage potential conflicts of interest between them and their parent firms (Burgelman, 1985; Dougherty, 1995). In this case, CVC unit maintains lower accountability to their parent firm, thus freeing the relationship with other business units (Birkinshaw and Hill, 2005; Sahaym, Cho, Kim, and Mousa, 2016). The autonomous CVC unit can make investment decisions, even if the target companies that the CVC unit intends to invest has seemingly no contribution in the short-run to the current business model of the parent firm

(Chesbrough, 2002; Siegel et al., 1988; Yang et al., 2016). Even though it is also possible when the start-ups on the investment target are potential competitors for other business units.

This type of CVC unit operates mostly in a form of a wholly owned subsidiary outside the parent firm and can make investment decisions independent of the current strategic interests of the parent firm. Google Ventures, a subsidiary of Google, is a typical example of this concept of independent CVC. Since this independent CVC unit typically usually establishes separate fund pools, it can be free from the restrictions on the investments by the parent company due to the insufficient resource situation (Birkinshaw and Hill, 2005). As a result, the independent CVC unit can pursue adventurous and aggressive investment decisions for the long-term advantage while leading to more variance performance.

In addition, the case of Samsung Electronics, which is the largest CVC investor in Korea, reveals the tendency of these innovation pattern. One of the interesting characteristics of Samsung Electronics' CVC investment activities is that it simultaneously operates the internal investment departments and independent CVC subsidiary outside the organization. In addition to Samsung Venture Investment Corporation (SVIC), a well-known CVC dedicated subsidiary of Samsung, it is also investing in start-ups through several internal divisions such as the Samsung Strategic Innovation Center (SSIC) and the Global Innovation Center (GIC). As such, Samsung's CVC investment units, which are operated both inside and outside of the parent firm, show different investment directions. In case of SVIC, although Samsung Electronics holds a 16.3% of total stake, it is investing

in technological areas that are somewhat apart from Samsung Electronics' core technology areas through relatively independent investment operations. In this respect, a typical investment field is bio-healthcare field. Samsung Venture Investment has recently invested in Noom, a startup that provides healthcare services. Noom is one of the leading innovators in preventive medicine services, and has been named Google's most innovative developer in 2009 and 2010. In 2017, it was officially certified by the US Centers for Disease Control and Prevention (CDC). Based on this technological ability, Noom already has 45 million users worldwide. From a long-term perspective, there are many prospects that the healthcare service will be able to generate synergies with Samsung Electronics' mobile wearable devices. In this way, SVIC provides Samsung Electronics and other subsidiaries with opportunities to get explorative innovation in a new direction that cannot be created by internal R&D activities.

In sum, since structurally autonomous CVC units can operate their investment portfolio freely independent from parent firms' strategic interests, they can manage more explorative investment for the long-term advantages in the future. From this point of view, I present the following hypothesis:

***Hypothesis 5-1****: The level of structural autonomy on CVC units has a positive relationship with corporate investor's explorative innovation performance.*

### 5.2.3 Structural autonomy of CVC unit and exploitation

As seen previously, the nature of learning activity for exploitation is much different from explorative activity. Gupta, Smith, and Shalley (2006, p.696) points out that “the learning, resources, and routines necessary for exploration and exploitation are different”. For these reasons, many firms often separate organizations for both exploration and exploitation. However, CVC investment as an external learning method can perform both exploration and exploitation functions. Since CVC requires a smaller amount of equity investment as compared to other external learning methods such as M&A, joint venture, and strategic alliance, it has relatively lower risks that investor should bear while having the possibility to diversify investment according to various strategic objectives (Benson and Ziedonis, 2009; Van de Vrande and Vanhaverbeke, 2013).

However, even with the same CVC unit, the way of operation that are more helpful for exploration and exploitation may be different. In particular, the level of the autonomy given to the CVC unit can have a completely different impact on exploitative learning. In order for firms to be successful in exploitation, it is important to use valuable resources, such as high-quality technical knowledge and skilled experts that they have accumulated over time, more than anything else (Hoang and Rothaermel, 2010; March, 1991). However, if the CVC unit is operated completely independent from the parent firm, there will be a structural disconnection from these valuable resources. The CVC unit maintains a certain distance from other departments in the firm that have valuable knowledge and skilled manpower, making it difficult to actively use these resources. This structural disconnection can be an

obstacle for CVC unit to finding target companies which have compatible knowledge that can effectively complement parent firms' existing knowledge (Hill and Birkinshaw, 2010). In addition, even if the CVC unit succeeds in finding a suitable target company, it is still difficult to achieve adequate innovation performance because of the lack of collaboration with experts in parent firm who can fully understand and use the acquired knowledge of target firm (Carnabuci and Operti, 2013; Cohen and Levinthal, 1990).

Therefore, although the autonomous CVC unit can guarantee self-directed searching activity while operating independently from the parent firm, it is difficult to expect high exploitative innovation performance because of its disconnection with the parent firm’s valuable cumulative resource.

As I mentioned earlier section, SSIC and GIC, which are internal investment departments of Samsung Electronics, are focusing on investment for exploitative innovation. They are relatively investing in areas close to core technology areas of Samsung Electronics. A recent example is investment in SoundHound in the US, which has been attracting attention as a speech recognition AI technology. SoundHound's technology, which provides a mobile app service that can search for music by humming sound, is expected to create a great synergy when it is combined with a smartphone launched by Samsung Electronics. In terms of speech recognition accuracy, SoundHound's technology is 95% accurate which is same level of Apple’s technology, Siri. Since Samsung Electronics is relatively weak in speech recognition technology, it is investing in SoundHound as a future acquisition target. As such, Samsung Electronics' investment through internal

divisions is seeking exploitative innovation to improve the performance of existing technologies and products.

From this perspective, I present the following hypothesis:

***Hypothesis 5-2****: The level of structural autonomy on CVC units has a negative relationship with corporate investor's exploitative innovation performance.*

### 5.2.4 Investor firm's technological diversity and innovation performance

While the structural autonomy of the CVC dedicated unit discussed above is an issue related to the operation of the investment, the issue of the corporate investor's technological diversity can be regarded as a discussion on the knowledge resource perspective. The availability of the knowledge resource to the firm, both internally and externally, play an important role in the innovation process (Das and Teng, 2000). To realize technological innovation, investor firms need to assimilate the newly sourced external knowledge and apply it to their own internal knowledge (Grant 1996; Kogut and Zander 1992). If investor firms successfully access their desired types of external knowledge pools by varying the CVC operation styles according to their strategic objectives, then they need to acquire, understand, and utilize appropriate technological knowledge from that knowledge pools. Even a firm with an abundance of technological knowledge from the external knowledge

sources may not be able to create technological innovation if it fails to adopt and internalize these resources as its own. Therefore investor firms that have access to portfolio companies that have valuable knowledge through CVC investments need absorptive capacity and dynamic capabilities to obtain the knowledge and technology from them (Cohen and Levinthal, 1990; Taylor and Greeve, 2006; Tushman and Rosenkopf, 1992; Fleming, 2001; Katila and Ahuja, 2002).

From this perspective, the diversity of investor firm's existing knowledge base plays an important role in the recombination process to create new innovations. A firm's technological diversity is significantly related with its absorptive capacity which shows a firm's ability to assimilate and apply the new information and technology (Zahra and George, 2002; Schildt, Keil, and Maula, 2012). A larger internal technological diversity allows for better recombination of knowledge of venture start-ups which is accessed through CVC investments.

In this vein, the investor firm's internal technological diversity can have a positive impact on both explorative and exploitative innovation. First, investor firm's internal knowledge diversity 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. Firms with highly diversified internal knowledge bases have previously unconnected pieces of knowledge which can be useful if these pieces are recombined into newly accepted external

knowledge (Wadwha and Kotha, 2006). In this case, the heterogeneity and diversity of technological knowledge increases the absorption of knowledges in multiple technological areas. Various knowledge pieces act as bridges between knowledge areas that are very distant from each other, thereby acting as a catalyst for exploitative innovation creation. In other words, an investor firm's simple pieces of existing knowledge that only have value under a specific context can develop new meanings and uses when it exposed to new contexts of innovation through CVC investment. Through this process, firms with diverse technical knowledge are better able to conduct exploitative innovation by advancing their existing technologies.

In addition, internal technological diversity also plays an important role in exploration. The diversity of knowledge allows investor firms not to stick to existing thought patterns rigidly and to pursue new and novel combination of thought. Firms with narrow knowledge pool tend to evolve their core capabilities to core rigidities (Leonard-Barton, 1992). Moreover the diverse knowledge enables flexible responses of firms to unpredictable environmental changes (March 1991; Van de Vrande and Vanhaverbeke 2013). Investor firms with diverse knowledge pools have a fluid mind-set that can take a novel approach to newly acquired technologies and knowledge. Bierly and Chakrabarti's (1996) research on new product development also shows that the ability to integrate knowledge in different technology areas is positively related to the diversity of the firm's existing knowledge pool. Therefore firms with more diversified technological knowledge base can leverage the knowledge gained through the CVC to create more novel and explorative innovations.

Hence, I can understand the role of the investor firm's internal technological diversity which positively related with the firm's innovation performance through CVC investments. This logic applies to both the exploration and exploitation of innovation performance, resulting in the following two hypotheses:

***Hypothesis 5-3****: A CVC investor firm's technological diversity has a positive relationship with corporate investor's explorative innovation performance.*

***Hypothesis 5-4****: A CVC investor firm's technological diversity has a positive relationship with corporate investor's exploitative innovation performance.*

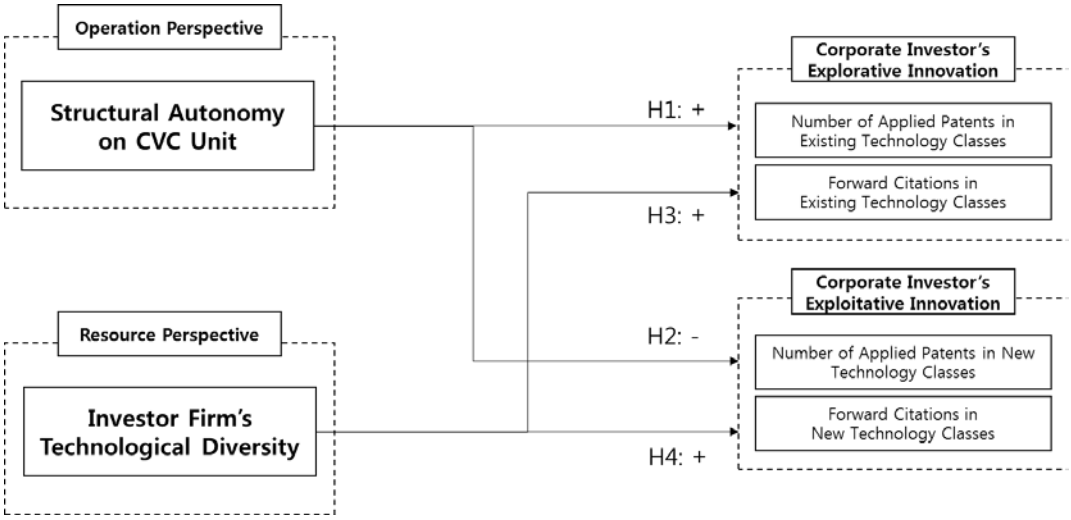


**Figure 5-1.** Conceptual Model for Chapter 5

The conceptual diagram in Figure 5-1 shows the relationships between the suggested hypotheses.

## 5.3 Methods

### 5.3.1 Data and sample

I analyzed the U.S. high-tech firms which have experienced CVC investment during the period from 1990 to 2010. Generally, since the rate of technology changes are faster in the high-tech industry compared to the low-tech industry, I believe firms engaging in high-tech industry will be more than likely to incentivize CVC investment.

I follow the classification of the high-tech industries provided by Securities Data Company (SDC) Platinum Database. According to Securities Data Company (SDC)'s industry classification data, the following seven industries are classified by the following groups: 'computer / IT', 'electrical & electronic / semiconductors', 'telecommunications / network', 'machinery / equipment', 'chemical / energy / material', 'biotechnology / pharmaceuticals / medical', and 'other technological services'. Next, I collect the sample of corporate investors from ThomsonOne.com PE/VC Module Database which contains the same information as VentureXpert, a tool extensively used in prior studies on VC. ThomsonOne.com PE/VC Module Database provides a list of CVCs and each investment round data. Since many investor firms established wholly owned subsidiaries (structurally autonomous units) or independent funds for their CVC investments, I 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.

Moreover, to investigate corporate investor's innovation performance, I used patenting data provided by the U.S. Patents and Trademarks Office (USPTO) database. I collected the number of applied patents and their forward citations. For identifying the patent classes of CVC investor's patent, the International Patent Classification (IPC)'s 3-digit code was used. Lastly, other data such as CVC parent firms' financial data and their M&A and alliance data were gathered from Compustat database provided by Standard and Poors and the Datastream database of Thomson Reuters. After gathering all variables and dropping samples that have missing data, the finalized panel consists of 318 firm-year observations with 77 sample firms.

## 5.3.2 Variables

### 5.3.2.1 Dependent variable

This study examines two different innovation performances, corporate investor's *Explorative Innovation Performance* and *Exploitative Innovation Performance*, as dependent variables. To measure these variables, corporate investor's patent application and forward citation data were used. Many prior researches used firm's patenting activities as a proxy to measure the rate of innovation (Ahuja 2000; Ahuja and Katila 2001; Dushnitsky and Lenox 2005; Wadhwa and Kotha, 2006).

In particular, Wadhwa and Kotha (2006) used the primary technology class (3-digit

patent class code) of corporate investor's patents to estimate the firm's innovative performance in specific technology area. This study follows this approach by estimating whether the prior technology class of newly applied patents after CVC investments is overlapped with corporate investor's existing classes or not. In other words, if the newly applied patent belongs to the existing primary technology classes which the corporate investor already owned, this is considered as the output of exploitative innovation. On the other hand, if the newly applied patent belongs to the new primary technology classes, which is not in the corporate investor's patent class pool, this is regarded as the output of the explorative innovation. Therefore, I counted the number of applied patents in corporate investor's existing technology class as *Exploitative Innovation Performance*, and the number of applied patents in newly generated technology class as *Explorative Innovation Performance*. Further, I counted the forward citations of applied patents to examine the qualitative aspects of the newly created innovation. Analysis of this quality of innovation is discussed in detail in the part of robustness test.

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, I 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 allows me to enhance the demonstration of the temporal order of cause and effect.

| Firm Name | Year (t) | primary id | Patent in Existing Technology Fields | Patent in New Technology Fields |
|---|---|---|---|---|
| Firm E | 2000 | 710 | | |
| Firm E | 2000 | 709 | | |
| Firm E | 2000 | 713 | | |
| CVC Investments in 2000 (t-1) | | | | |
| Firm E | 2001 | 713 | 1 | 0 |
| Firm E | 2001 | 375 | 0 | 1 |
| Firm E | 2001 | 341 | 0 | 1 |
| Firm E | 2001 | 709 | 1 | 0 |
| Firm E | 2002 | 370 | 0 | 1 |
| Firm E | 2002 | 375 | 0 | 1 |
| Firm E | 2002 | 710 | 1 | 0 |
| Firm E | 2003 | 710 | 1 | 0 |
| Firm E | 2003 | 713 | 1 | 0 |
| Firm E | 2003 | 439 | 0 | 1 |
| Firm E | 2003 | 370 | 0 | 1 |
| Firm E | 2003 | 709 | 1 | 0 |

**Firm E's Exploitative Innovation Performance (2001 to 2003) = 6 (713, 709, 710, 710, 713, 709 Class Patents)**

**Firm E's Explorative Innovation Performance (2001 to 2003) = 6 (375, 341, 370, 375, 439, 370 Class Patents)**

**Figure 5-2.** Explorative and Exploitative Innovation Coding Example

#### 5.3.2.2 Independent variables

This study use two independent variables. The first one is *CVC Unit's Structural Autonomy.* Most of prior researches measured structural autonomy of CVC unit by using survey data (Birkinshaw and Hill, 2005; Hill and Birkinshaw, 2008). However, some recent

researches such as Yang et al. (2016) and Kang and Park (2015, working paper) used the archival data collected from electronic database. Yang et al. (2016) classified CVC programs into two categories in the VentureXpert database: 1) an internal program with direct investment from parent corporate investor, and 2) a wholly owned independent subsidiary for CVC, which presents two different levels of structural autonomy. According to their arguments, managers of internalized CVC program have less autonomy in investment process because this kind of investment can be closely aligned with parent firm's strategic attentions. Therefore, if the potential investment target company is too far away from the parent firm's interest, or if it is determined that there is a possibility of harming the existing business, the investment may be withdrawn.

On the other hand, a firm which operates structurally independent subsidiary gives CVC managers greater autonomy to manage the investment activities. Thus, the authors make one dichotomous variable to indicate whether a CVC program is an internal program or an independent subsidiary as a proxy for the structural autonomy level. Value 1 was assigned to the investment undertaken by independent CVC subsidiary, and value 0 was assigned to the internal CVC program's direct investment. Additionally, this study follows this approach to measure *CVC Unit's Structural Autonomy*. As a result, in this study, a corporate investor's annual CVC structural autonomy level is measured by the average value of each investment's structural autonomy which is distributed between 1 and 0.

The second independent variables of this study is *Investor's Technological Diversity* As a proxy of technological diversity, 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. This study follows this approach by estimating a focal firm's post CVC technological diversity. At the first, I count the total number of primary (3-digit patent class code) technology classes in which it applied for a patent, and then calculate the Herfindahl–Hirschman Index (HHI) using the proportion of patents in each category of patent classes.

#### 5.3.2.3 Control variables

In addition to the independent variable, there are other parameters that can affect a corporate investor's innovation performance, prompting me to add a number of control variables. First, I controlled for the corporate investor's size based on its total sales because larger firms may have more resources to generate innovative outputs. In addition, the amount of R&D expenditure can show the engagement of a firm in innovative activities. Therefore, I controlled for natural log of firm i's total sales and total R&D expenditure in year t-1 as a proxy of *Firm Size* and *R&D Expenditure*.

At the strategy level, I controlled for number of previous M&A and alliance experience. Since M&A's and strategic alliances are other types of external knowledge sourcing strategies, they can affect the corporate investor's innovation performance. From the

resource-based view, too much investment into M&As or alliance deals can hinder the overall CVC activities because of limited resources. From a different point of view, since abundant experiences with M&As or alliances could mean that the firm is familiar with external sourcing strategies, and thus might use CVC investments more actively. Therefore, I controlled for the total number of *M&A Experience* and *Alliance Experience* in year t-1.

At the CVC program level, I controlled for the *Amount of CVC Investment*, the *Number of CVC Portfolio Industry*, and the number of co-investors to investigate the *Quality of Portfolio Companies* (Wadhwa and Kotha, 2006). *The Amount of CVC Investment* was transformed to log scale and CVC program level control variables were measured at year t-1 (in the case of *Quality of Portfolio Companies*: t-1 to t-3).

Finally, a *Fixed Effect of Industry* was also controlled because different industries are likely to have different interests in the type of innovation. For example, in the case of IT industry, due to shorter technological life-cycles, the importance of explorative innovation for radical change is relatively higher than for other industries. This could raise the possibility of corporate investors in certain industries being more active in the pursuit of CVC investments in explorative knowledge areas. Therefore, I controlled for the fixed effects of the seven different industries by introducing dummy variables for each industry.

### 5.3.3 Statistical model

*Explorative and Exploitative Innovation Performances*, the lagged dependent variables

of this study, are count variables which are calculated from the number of newly applied patents and do not have negative values. Thus, I decided to use a negative binomial regression model which one of the nonlinear model commonly used to avoid heteroscedasticity problems (Hausman, Hall, and Griliches, 1984; Wadhwa and Kotha, 2006). The negative binomial regression model is a generalized form of the Poisson model. In comparison to 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 over-dispersion. Since the standard deviations of dependent variables (9.538 of explorative performance, and 669.217 of exploitative performance) are larger than their mean values (9.519 and 466.182), I chose the negative binomial model.

In the panel data of this study, some unobserved or unmeasured terms exist. To correct the heteroscedasticity problem stemming from these unobserved characteristics, fixed-effects and random-effects estimations can be used. Therefore, I conducted a Hausman test (Hausman, Hall, and Griliches 1984) to check which estimation model is more appropriate. As a result, the relationships between the property effects of each variable and the dependent variable of this study were statistically insignificant, thus random-effect estimation is more suitable for the panel data of this study.

**Table 5-1.** Variable descriptions

| Variables | Measures |
|---|---|
| Explorative Innovation Performance | (1) Number of applied patents (2) forward citations in newly generated technology class |
| Exploitative Innovation Performance | (1) Number of applied patents (2) forward citations in corporate investor's existing technology class |
| CVC Unit's Structural Autonomy | Average value of each investment's structural autonomy (corporate investor's direct investment = 0, indirect investment through independent CVC unit = 1) |
| Investor's Technology Diversity | Herfindahl–Hirschman Index (HHI) using the proportion of patents in each category of patent classes in last year |
| Firm Size | Natural log of total sales in last year |
| R&D Expenditure | Natural log of total R&D expenditure in last year |
| M&A Experience | Number of M&A deals in last year |
| Alliance Experience | Number of alliance deals in last year |
| Amount of CVC Investment | Natural log of total CVC investment |
| Number of CVC Portfolio Industry | Total number of industry sectors where target companies in CVC portfolio are engaged in |
| Quality of Portfolio Companies | Cumulative number of co-invested VCs in last 3 years |

## 5.4 Results

### 5.4.1 Descriptive statistics and correlations

Table 5-2 represents the descriptive statistics of two dependent variables and all the independent variables and control variables used in this study and the correlations between them. The average of the first dependent variable Explorative Innovation Performance is 9.519, and second dependent variable Exploitative Innovation Performance is 466.182. I can observe that most of newly applied patents are in corporate investor's existing technology areas. In regard to the structural autonomy of CVC unit, about 59.4% of CVC deals were undertaken by structurally independent CVC units.

The correlation results between the variables of this study shows that the number of previous M&A experiences is highly correlated with strategic alliance experience (correlation factor: 0.603). In addition, other control variables such as the number of industries in CVC portfolio and the number of co-investors are highly correlated (correlation factor: 0.863). These high correlation results could be the factors that give raise to a multicollinearity problem in the process of regression. In order to check for the presence of any multicollinearity problem, I additionally performed Variance Inflation Factor (VIF) test. As a result of the test, the low VIF values (average of 2.36, maximum of 5.47) indicate that the sample does not have any problem with multicollinearity. Moreover, although two independent variables of exploitative innovation performance (number of

newly applied patents and forward citations in existing technology classes) highly correlated (correlation factor: 0.846), this correlation does not affect the regression results because these two variables are not included in same regression model.

**Table 5-2.** Descriptive statistics and correlations matrix of the variables

| | Variable | Mean | S.D. | Min | Max | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Explorative Innovation Performance (# of patents) | 9.519 | 9.538 | 1 | 84 | 1.000 | | | | | | | | | | | | |
| 2 | Exploitative Innovation Performance (# of patents) | 466.182 | 669.217 | 1 | 4063 | 0.430 | 1.000 | | | | | | | | | | | |
| 3 | Explorative Innovation Performance (# of forward citations) | 20.116 | 31.774 | 0 | 250 | 0.598 | 0.296 | 1.000 | | | | | | | | | | |
| 4 | Exploitative Innovation Performance (# of forward citations) | 1159.258 | 2116.136 | 0 | 14556 | 0.340 | 0.846 | 0.399 | 1.000 | | | | | | | | | |
| 5 | CVC Unit's Structural Autonomy | 0.594 | 0.476 | 0 | 1 | 0.325 | -0.013 | 0.218 | -0.049 | 1.000 | | | | | | | | |
| 6 | Investor's Technological Diversity | 0.814 | 0.176 | 0 | 0.980 | 0.441 | 0.417 | 0.271 | 0.329 | 0.165 | 1.000 | | | | | | | |
| 7 | Firm Size | 9.110 | 1.866 | 1.366 | 12.106 | 0.422 | 0.474 | 0.205 | 0.337 | 0.380 | 0.447 | 1.000 | | | | | | |
| 8 | R&D Expenditure | 6.455 | 1.964 | 0 | 9.106 | 0.324 | 0.475 | 0.144 | 0.320 | 0.049 | 0.534 | 0.252 | 1.000 | | | | | |
| 9 | M&A Experience | 4.686 | 5.451 | 0 | 44 | 0.145 | 0.399 | 0.172 | 0.491 | -0.019 | 0.343 | 0.279 | 0.209 | 1.000 | | | | |
| 10 | Alliance Experience | 6.296 | 10.736 | 0 | 97 | 0.085 | 0.553 | 0.187 | 0.681 | -0.089 | 0.287 | 0.251 | 0.603 | 0.201 | 1.000 | | | |
| 11 | Amount of CVC Investment | 3.168 | 1.674 | 0 | 7.760 | 0.123 | 0.171 | 0.027 | 0.101 | 0.206 | 0.260 | 0.243 | 0.252 | 0.151 | 0.142 | 1.000 | | |
| 12 | Number of CVC Portfolio Industry | 4.343 | 6.954 | 1 | 59 | 0.153 | 0.284 | 0.128 | 0.258 | 0.191 | 0.278 | 0.266 | 0.358 | 0.179 | 0.203 | 0.614 | 1.000 | |
| 13 | Quality of Portfolio Companies | 95.412 | 219.617 | 0 | 1792 | 0.108 | 0.276 | 0.047 | 0.209 | 0.193 | 0.246 | 0.255 | 0.175 | 0.076 | 0.170 | 0.511 | 0.863 | 1.000 |

Note: N=318. Dummy variables were excluded.

### 5.4.2 Regression results

Table 5-3 shows the results of the random effects negative binomial regression model. Model 1 and Model 3 is the unconstrained model which only includes the control variables on the condition of excluding the independent variables. The dependent variable of Model 1 is corporate investor's Explorative Innovation Performance. In Model 1, the coefficients of Firm Size is significant, i.e. I find that the large firms tend to generate more patents in the new technology areas.

Model 2 and Model 4 additionally include two independent variables (CVC Unit's Structural Autonomy and Investor's Technological Diversity) to test hypotheses. Hypothesis 1 predicts a positive relationship between the structural autonomy on CVC unit and corporate investor's explorative innovation. I argued that the higher level of structural autonomy on CVC unit can increase the number of newly applied patents in the new technology areas that do not overlap with the patent classes corporate investors already have. In Model 2, I find a positive and statistically significant relationship between CVC Unit's Structural Autonomy and corporate investor's explorative innovation ($b=0.330, p<0.01$), which is consistent with Hypothesis 1.

Hypothesis 2 predicts a negative relationship between the structural autonomy on CVC unit and corporate investor's exploitative innovation. In my opinion, highly autonomous CVC unit can have a negative impact on exploitative innovation because it is also disconnected from parent firm's valuable resources such as the some professional expertise, accumulated

technology, tacit knowhow, and networks. In Model 4, the coefficient of structural autonomy on CVC unit is negative and statistically significant ($b=-0.257, p<0.05$), which is consistent with Hypothesis 2.

Hypothesis 3 and 4 predicts positive relationships between the investor firm's technological diversity and both of innovation performance; exploration and exploitation. I argued that the higher level of investor's technological diversity may increase the number of patents in newly accessed technology areas and familiar fields. In Model 2, I find a positive and statistically significant relationship between Investor's Technological Diversity and subsequent explorative innovation ($b=2.135$, $p<0.001$), which is consistent with Hypothesis 3. Moreover, in Model 4, I also found a positive and statistically significant relationship between Investor's Technological Diversity and subsequent exploitative innovation ($b=2.098$, $p<0.001$), which is consistent with Hypothesis 4. These results show that as corporate investors have more knowledge about various technology fields, the ability to acquire knowledge of entirely new areas is increased, and at the same time, the ability to create new innovations by recombining them with existing knowledge is also improved.

**Table 5-3.** Regression results (Negative binomial regression models)

| ***Dependent Variables*** | **Explorative Innovation Performance** (# of patents) | | **Exploitative Innovation Performance** (# of patents) | |
|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 4** |
| ***Control Variables*** | | | | |
| Firm Size | 0.176*** | 0.0820* | -0.058 | 0.034 |
| | (0.041) | (0.041) | (0.055) | (0.056) |
| R&D Expenditure | -0.022 | 0.000 | 0.031 | 0.035 |
| | (0.040) | (0.037) | (0.063) | (0.057) |
| M&A Experience | 0.011 | 0.012 | 0.011 | 0.012 |
| | (0.009) | (0.008) | (0.008) | (0.007) |
| Alliance Experience | -0.003 | -0.004 | 0.005 | 0.000 |
| | (0.004) | (0.004) | (0.005) | (0.004) |
| Amount of CVC Investment | -0.048+ | -0.047 | -0.024 | -0.016 |
| | (0.027) | (0.025) | (0.027) | (0.026) |
| Number of CVC Portfolio Industry | 0.017 | 0.014 | 0.003 | 0.000 |
| | (0.010) | (0.009) | (0.008) | (0.008) |
| Quality of Portfolio Companies | -0.001 | -0.001 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Industry Dummies | Included | Included | Included | Included |
| _Cons | -0.465 | -1.502** | -0.484 | -2.590*** |
| | (0.554) | (0.534) | (0.711) | (0.777) |
| ***Independent Variables*** | | | | |
| CVC Unit's Structural Autonomy | | 0.330** | | -0.257* |
| | | (0.118) | | (0.123) |
| Investor's Technological Diversity | | 2.135*** | | 3.183*** |
| | | (0.405) | | (0.531) |
| Observations | 318 | 318 | 318 | 318 |
| Log-Likelihood | -927.447 | -911.954 | -2003.426 | -1972.032 |
| Wald $\chi^2$ | 54.21*** | 100.85*** | 55.13*** | 116.55*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |

Note: N=318. ***p<0.001; **p<0.01; *p<0.05

### 5.4.3 Robustness test

I tested regression analysis using other measure of dependent variable. As I explained above, I used corporate investors' forward citation data as an alternative measurement of innovation performance. The use of citation-weighted patent data has the advantage of being able to measure not only quantitative but also qualitative aspect of innovation performance at the same time (Dushnitsky and Lenox, 2005; Hagedoorn and Cloodt, 2003; Trajtenberg, 1990). For this reason, patent citations are commonly used in recent studies to measure the firm's innovation performance.

Table 5-4 shows the full results of additional regression analysis with corporate investor's patent citation performances. I can find that CVC unit's structural autonomy has positive and statistically significant relationship with corporate investor's patent citations in newly generated technology area (exploration), while it has negative and statistically significant relationship with the patent citations in existing technology area (exploitation). In addition, corporate investor's technological diversity has positive and significant relationships with both of explorative and exploitative innovation performances. These results are same with the previous results using number of applied patents, thus the hypotheses can be regarded as robust in both of the quantitative and qualitative dimensions of innovation performances.

**Table 5-4.** Robustness test (Negative binomial regression models for forward citations)

| *Dependent Variables* | **Explorative Innovation Performance** (forward citations) | | **Exploitative Innovation Performance** (forward citations) | |
|---|---|---|---|---|
| | **Model 5** | **Model 6** | **Model 7** | **Model 8** |
| ***Control Variables*** | | | | |
| Firm Size | 0.114<br>(0.044) | 0.017<br>(0.049) | -0.057<br>(0.054) | -0.029<br>(0.059) |
| R&D Expenditure | -0.068<br>(0.044) | -0.052<br>(0.044) | 0.002<br>(0.056) | -0.009<br>(0.054) |
| M&A Experience | -0.004<br>(0.013) | 0.000<br>(0.013) | 0.005<br>(0.011) | 0.008<br>(0.011) |
| Alliance Experience | 0.013<br>(0.006) | 0.011<br>(0.006) | 0.018**<br>(0.005) | 0.014**<br>(0.005) |
| Amount of CVC Investment | -0.074<br>(0.044) | -0.071<br>(0.043) | -0.036<br>(0.041) | -0.025<br>(0.040) |
| Number of CVC Portfolio Industry | 0.031<br>(0.018) | 0.028<br>(0.018) | 0.022<br>(0.015) | 0.015<br>(0.015) |
| Quality of Portfolio Companies | -0.001<br>(0.001) | -0.001<br>(0.001) | 0.000<br>(0.000) | 0.000<br>(0.000) |
| Industry Dummies | Included | Included | Included | Included |
| Cons | -1.226*<br>(0.542) | -2.212***<br>(0.586) | -0.027<br>(0.704) | -1.905*<br>(0.773) |
| ***Independent Variables*** | | | | |
| CVC Unit's Structural Autonomy | | 0.320*<br>(0.158) | | -0.418**<br>(0.162) |
| Investor's Technology Diversity | | 2.145***<br>(0.529) | | 2.098***<br>(0.554) |
| Observations | 318 | 318 | 318 | 318 |
| Log-Likelihood | -1193.878 | -1183.944 | -2283.232 | -2268.549 |
| Wald $\chi^2$ | 42.73***<br>(0.000) | 61.17***<br>(0.000) | 66.53***<br>(0.000) | 100.27***<br>(0.000) |

Note: N=318. ***p<0.001; **p<0.01; *p<0.05

In addition, based on a web-based database of Korean domestic CVC investment, The VC (thevc.kr), I examined the relationships of structural autonomy and the investment propensities of Korean top 33 CVCs. The VC provides information on the types of venture investors, preferred investment fields, preferred investment series (investment stage), total investment amount, and total number of investments. Table 5-5 shows the investment characteristics of 33 CVC firms in Korean market.

As a result of comparing structural autonomy level and explorative learning status among 33 CVCs, 20 CVC firms showed explorative learning as higher structural autonomy and exploitative learning as lower structural autonomy. For example, POSCO Capital which is POSCO's subsidiary for CVC investment can be viewed as an independent CVC unit with high-level of structural autonomy, and it preferred explorative learning activity through CVC with unfamiliar investment area such as bio/pharma technology field. On the other hand, NC Soft, a game developer, invested directly without CVC subsidiaries, and preferred investment was in the same game industry as its core business. These observations results follow the hypotheses of Study 3 which argue that the types of learning activities through CVC investment vary depending on the degree of CVC dedicated unit's structural autonomy. The remaining 13 CVC firms did not follow this tendency. Although 33 samples were small, 20 cases (about 61%) out of 33 cases showed the investment behavior suggested in this study.

**Table 5-5.** CVC firms in Korean market

| CVC | Established Year | Parent Firm | Autonomy | Parent Firm's Primary Tech. Field | Preferred Investment Field | Preferred Investment Stage | Explorative Learning |
|---|---|---|---|---|---|---|---|
| POSCO Capital | 1997 | POSCO | 1 | Steel | Bio/pharma | pre-A | 1 |
| Samsung Venture Investment Corp. | 1999 | Samsung | 1 | Electronics | Travel | B | 1 |
| Neoplux | 2000 | Doosan | 1 | Machinery | Bio/pharma | B | 1 |
| Naver | 1997 | Naver | 0 | Search engine, Portal | Game | D | 0 |
| Mega Investment | 2012 | Mega Study | 1 | Education | Life | B | 0 |
| GS Home Shopping | 1994 | GS Home Shopping | 0 | Home Shopping | Contents | A | 0 |
| KAKAO | 2006 | KAKAO | 0 | Mobile Messenger | Food | pre-A | 1 |
| Hanhwa Investment | 1962 | Hanhwa | 1 | Gunpowder, IT, Finance | Bio/pharma | B | 1 |
| NC Soft | 1997 | NC Soft | 0 | Game | Game | A | 0 |
| SK Planet | 2011 | SK Planet | 0 | Electronic commerce | Agriculture | A | 1 |
| Koron Investment | 2000 | Koron | 1 | Textile manfacturing | Bo | B | 1 |
| NHN Entertainment | 2013 | NHN Entertainment | 0 | Game | Shopping | A | 1 |
| Intel Capital | 1991 | Intel | 1 | Electronics | Enterprise | B | 1 |
| Timewise Investment | 2000 | CJ | 1 | Contents, Food | Buty | A | 1 |
| KAKAO Games Holdings | 2015 | KAKAO | 0 | Mobile Messenger | Automobile | B | 1 |
| Tencent | 1998 | Tencent | 0 | Game | Game | D | 0 |
| SK Telecom | 1984 | SK Telecom | 0 | Telecommunication | Life | A | 1 |
| NXC | 1989 | NXC | 0 | Game | Contents | pre-A | 0 |
| Danal | 1997 | Danal | 0 | Mobile payment | Shopping | pre-A | 0 |
| Spring Camp | 2016 | Snow | 1 | Mobile contents | Enterprise | Seed/angel | 1 |
| Humax Holdings | 1989 | Humax | 0 | Electronics | Food | C | 1 |
| LG U+ | 1996 | LG U+ | 0 | Telecommunication | Enterprise | C | 1 |
| POSCO | 1968 | POSCO | 0 | Steel | Shipp building | Seed/angel | 0 |
| Neowiz Investment | 2007 | Neowiz | 1 | Game | Contents | pre-A | 0 |
| DeNA | 1999 | DNA | 0 | Game | Life | - | 1 |
| Line | 2000 | Line | 0 | Mobile Messenger | Contents | A | 0 |
| Samsung Electronics | 1969 | Samsung Electronics | 0 | Electronics | Life | D | 1 |
| Softbank | 1981 | Softbank | 0 | Financem, Investment | Shopping | C | 1 |
| Wemade Entertainment | 2000 | Wemade Entertainment | 0 | Game | Game | A | 0 |
| Innobase | 2005 | Koron | 1 | Investment | Shopping | Seed/angel | 1 |
| Nexon Korea | 1994 | Nexon Korea | 0 | Game | Game | B | 0 |
| Delevery Hero | 2011 | Delevery Hero | 0 | Mobile food delevery | Food | D | 0 |
| Rakuten Ventures | 2014 | Rakuten | 1 | Internet shopping | Enterprise | pre-A | 1 |

Source: Modify the raw data provided by 'The VC (thevc.kr)'

## 5.5 Discussions

This chapter investigates the impacts of CVC unit's structural autonomy and investor firm's technological diversity on corporate investor's two kinds of innovation: exploration and exploitation. It examined the effect of CVC unit's structural autonomy as an accelerator of corporate investor's explorative innovation with relatively free and adventurous investments. On the other hand, in the case of exploitative innovation, I analyzed the role of structural autonomy as an inhibitor by disconnecting CVC unit from parent firm's valuable resources. In addition, in resource perspective, I postulate that investor firm's internal technological diversity is positively related with both of the exploration and exploitation. I analyzed empirical data of 77 U.S. high-tech firms that have experienced in CVC investments between 1990 and 2010. All results of empirical analysis support the hypotheses. I increased the quality of empirical results by controlling for other potential factors that might influence corporate investor's innovation performance such as firm size, R&D expenditure, M&A and alliance experiences, and other CVC deal-related determinants.

This study provides some valuable insights for several streams of literature. First, this study contributes to the small but growing literature of what organizational structure can help to achieve innovative performance (Hill and Birkinshaw, 2014). More specifically, this study has provided a detailed understanding of role of CVC investments as an innovation strategy by dividing the innovation performance into exploration and

exploitation. While previous literature has acknowledged the relationship between CVC investment and corporate investor's innovation performance, most of them tend to focus solely on the CVC's boundary-spanning function to capture new business opportunities and technological discontinuities (Maula, Keil, and Zahra, 2013; Thompson, 1967). Unlike these previous studies, this study reexamines the role of CVC investment as an exploitative learning method that strengthens the existing business of corporate investors. As many corporate investors respond to the survey for both exploratory and exploitative purposes, CVC investment can be characterized by ambidextrous learning method. This ambidextrous nature of CVC investment is an important factor affecting the survival of the CVC unit from a long-term perspective by influencing the size and type of innovation performance that can be achieved through the CVC (Hill and Birkinshaw, 2014). Moreover, since the viability of CVC unit can ultimately affect the long-term performance of corporate investor, a more in-depth consideration is needed.

Second, this study also provide more detailed understanding of the organizational operation of CVC investment. Specifically, I focus on the role of structural autonomy on CVC unit. Over the course of the years, several studies have discussed the strategic value of structural autonomy given to the CVC unit. Siegel et al. (1988) argued that the autonomous CVC unit, which is entrusted with full authority over the investment from the parent firm, can enjoy higher investment performance because it can move away from various corporate interferences and react more aggressively to investment opportunities. Moreover, Birkinshaw and Hill (2005) argued that autonomous CVC unit can be free from

the restrictions of investment by the parent firm’s insufficient resource situation because it usually established a separate fund pool. Recently, Yang et al. (2016) shows that structural autonomy of a CVC program is significantly related to its investment portfolio diversification. However, there are few studies that classify the impact of CVC's structural autonomy on explorative innovation and exploitative innovation of corporate investor. This study can provide a way to operate an ambidextrous CVC from a long-term perspective by carefully examining the role of structural autonomy that influences decision-making processes before investment and post-CVC knowledge acquisition process.

Third, this study shed lights on the importance of internal technological diversity of corporate investors to achieve pleasing level of innovation performance through CVC investments. The technological diversity of the corporate investor allows the CVC to better understand and utilize the newly acquired external knowledge. In other words, since a firm with a diversified knowledge base may have higher absorptive capacity, it can maximize the strategic benefits of CVC investments. This study empirically found that technological diversity positively affects both exploitation and exploration of CVC investor firms. This result implies an academic implication that this study have considered innovation strategies through CVC investment in both the operational and resource aspects of the enterprise.

Fourth, this study contributes to the development of the literature on innovation strategy in that it carried out an empirical analysis that takes into account both quantitative and qualitative dimensions of innovation performance. I did not only look at how many patents were created after CVC investments, but also analyzed how many other patents cite the

corporate investor’s patents. The result of the analysis shows that the quality of newly created innovations may be different according to the level of autonomy given to CVC investment. This may be an important challenge for both scholars who study CVC as firm’s innovation strategy, and the firms who actually perform CVC investment.

Finally, this study suggests a managerial implication that can be used by the corporate investors. Through the analysis result of this study, I can provide the following strategic suggestions the firms. First, in the target searching phase before the actual investment takes place, CVC unit must ensure whether the industry in which the potential target company belongs and the knowledge they have are on the extension of the existing business model of parent firm or not. If the potential target company is engaged in an area completely unrelated to the parent firm's existing business, the delegation of the entire autonomy of investment activities to the CVC unit will be a better strategy for achieving higher explorative innovation performance. On the other hand, if the potential target company's business items and technologies are on the extension of the parent company's existing business, it would be more advantageous to invest in close relationships with the parent firm's relevant departments rather than grant full autonomy to the CVC unit. In particular, if the CVC unit is operated independently from outside the organization in the form of a wholly owned subsidiary, it may be effective to divide the CVC unit itself into separate organizations for explorative and exploitative activities. In this case, the organization for exploitation should be able to form a closer relationship with the experts and technical resources of the parent firm.

# Chapter 6. Conclusive remarks

## 6.1 Summary and contributions

In conclusion, the present dissertation highlights the comprehensive view of corporate venture capital (CVC) investments that can contribute to the corporate investor's innovation performance. Specifically, this dissertation focuses on the role of CVC investments as a method of external knowledge sourcing strategy. In today's high-tech industries, small venture start-ups which have creative ideas and flexible decision making process are becoming as an important element of innovation. Incumbent firms can access valuable knowledge from those start-ups in emerging technology area through active CVC investments. Indeed, many global IT companies such as Intel, Google and Qualcomm, as well as some bio-medical companies like Pfizer and Biogen, are using CVC investments as an important innovation strategy.

Table 6-1 summarizes what topics and research questions each of the three studies constituting this dissertation deal with, how each study deals with innovation, and the statistical methods and data bases used by each study .

**Table 6-1.** Summary of Each Study

| | Study 1 (Chapter 3) | Study 2 (Chapter 4) | Study 3 (Chapter 5) |
|---|---|---|---|
| **Topic** | Technological Diversification through CVC Investments | Organizational Determinants of CVC Portfolio Diversification | Exploration and Exploitation through CVC Investments |
| **Research Question** | Does CVC investment influence on the expansion of investor's technological diversity? | What are the organizational antecedents that determine the CVC portfolio diversity? | How the level of the structural autonomy given to the CVC dedicated unit and investor firm's internal technological diversity affect the two different kinds of innovation: exploration and exploitation? |
| **Dimension of Innovation** | Innovation Diversity | Innovation Diversity | Exploration & Exploitation |
| **Method** | Negative binomial regression | Generalized least square regression | Negative binomial regression |
| **Data Base** | ThomsonOne.com PE/VC Module, SDC Platinum, DataStream, USPTO patent database | ThomsonOne.com PE/VC Module, SDC Platinum, DataStream, USPTO patent database, Corporate Affiliations of Lexis-Nexis & Who's Who of Marquis | ThomsonOne.com PE/VC Module, SDC Platinum, DataStream, USPTO patent database, Corporate Affiliations of Lexis-Nexis & Who's Who of Marquis |

As the interest in the value of CVC investments as a learning strategy for innovation creation increases, this dissertation empirically examines whether corporate investors actually generate innovation performance through CVC investments. Moreover, this dissertation looks at how organizational structures of CVC units should be formed by corporate investors in order to achieve the desired investment performance consistent with their strategic objectives. Specifically, this dissertation provides the following key academic contributions and some managerial implications:

First, this dissertation presents the academic framework for the follow up study by interpreting the decision making process of CVC investment, which has some non-scientific factors, as scientific variables and practical cases. A firm's strategic activities such as CVC investment have many factors that cannot be measured by scientific metrics such as individual tendency or preference, organizational culture, and social atmosphere, and there are many cases in which unreasonable and non-logical choices are made. No matter how good technology a start-up has, corporate investors may not be able to make the actual investment if it do not meet the preferences of the final decision maker who makes CVC investment decisions. However, in order to create an academic research, it is necessary to present scientific variables to indirectly proxy various factors that influence decision making, and to provide a case study to show the corporate investors' practical decision-making process. In this respect, this study implies that the strategic activities of CVC investment are systematically analyzed through various scientific variables and actual company cases. Ultimately, in strategic CVC investments aimed at technological

innovation through external knowledge acquisition, this dissertation develop an academic framework that following researchers can refer to by analyzing the effect of some scientific measures such as structural autonomy, TMT characteristics, absorptive capacity, and organizational slack.

Second, based on the findings of Chapter 3, this dissertation sheds light on the relationship between a firm’s CVC investment and its technological diversification. In the meantime, many practitioners were responding to the expansion of the 'technological window' as one of the strategic goals for firms to invest in CVC through survey responses. In other words, they are investing in CVCs in order to expand the technological boundaries of them by accessing new knowledge sources of portfolio companies and to increase the number of strategic options available for future use. Therefore, there is a clear need to deal with the boundary spanning effect of knowledge base in the academic study of innovation strategy through CVC investments. However, most of the existing studies that have addressed innovation strategies through CVC investments have concentrated on quantitative aspects of innovation performance, and there have been few studies that have analyzed empirically the diversity issue. In contrast, this study interprets technological diversification as an important performance variable for innovation activities. James G. March, an early adopter of organizational learning, has also emphasized the diversity of knowledge base as a key point for firms to survive in today's highly uncertain environment. Moreover, since the diversity of technology can be measured after the generation of new innovation (new patent) with its technology class information, we can consider that

technology diversity as a characteristics variable of newly generated innovation. In this vein, as a results of empirical analysis, 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. This analysis results provides a managerial implication to practitioners that corporate investors should not neglect efforts to increase the absorptive capacity of firms such as internal R&D to

maximize the effects of technological diversification through CVC investments.

Third, Chapter 4 of this dissertation examines the relationships between three organizational factors and CVC portfolio diversification. As a result of empirical analysis, a negative relationship was found between the CVC parent firm's TMT homogeneity and CVC portfolio diversity. A similar relationship was also found between the CVC parent firm's organizational slack resource constraints and the resulting diversity of the CVC portfolio. On the contrary, I found a positive relationship between the structural autonomy of the CVC dedicated unit and CVC portfolio diversity.

These results suggest that some organizational antecedent factors such as the individual characteristics of TMT members in CVC parent firm and its financial situation can be critical obstacles for operating diversified CVC portfolios. Thus, if an incumbent firm planning CVC investments wants to access start-ups that are engaged in more diverse knowledge areas, it can be seen that CVC dedicated units must be freed from such organizational obstacles by operating as an independent subsidiary. In fact, Google, one of the firms that most actively utilizes CVC investments, can operate highly diversified industry portfolios consist with not only internet but also health care, robotics, data management, and artificial intelligence through independent subsidiary for CVC investments – GV (formerly Google Ventures).

Fourth, Chapter 5 deals with an argument that the direction of the innovation achievement obtained by corporate investor may vary depending on how the organization for CVC investment is operated. Previous studies which conducted empirical analysis of

the effects of CVC investments on an investor firm's innovation performance have largely focused only on their role as explorative learning methods and have overlooked the fact that incumbent firms can also perform exploitative learning through CVC investments. Since CVC investments have the advantage of having access to the valuable knowledge pools outside of the firm with relatively small equity investment compared to other external knowledge sourcing strategies such as M&As, strategic alliances, and joint ventures, incumbent firms are able to divide the funds they can invest, and then perform CVC investment in new areas of knowledge that they do not know well and some areas of expertise they already know simultaneously. In other words, CVC investments can serve as an ambidextrous strategy.

The innovation output of explorative learning and exploitative learning have different directions, so the way of operating CVC investments for them must also be different. In particular, the structural autonomy given to departments dedicated to CVC investment can change the nature of the learning activity that the department seeks. As a result of an empirical analysis of the relationship between structural autonomy and two different types of innovation output - exploration and exploitation, the independent CVC unit with high level of autonomy is good at explorative learning but not expository learning. The reason for this difference is that the autonomy granted to the CVC dedicated unit is helpful for the courageous investment in the new knowledge field, but it results in a break with valuable knowledge and human resources accumulated within the parent firm organization. Therefore, incumbent firms that want to invest in start-ups need to clarify what kinds of

innovations they want to create before selecting investment targets. If a firm wants to pursue freedom and diversity of investment, it is effective to operate the CVC dedicated unit outside the parent firm organization. On the contrary, if a firm want to pursue efficiency and professionalism of investment, it better to operate CVC dedicated unit directly and closely in parent firm organization.

Collectively, this study provides a comprehensive overview of the entire decision-making process for firms seeking to invest in CVC through three different levels of research. The three studies that make up this dissertation are not individual studies that are not related to each other, but each causal variable and outcome variable are linked to other study's variables. Practitioners planning CVC investment will use this study as a starting point to consider what organizational factors should be taken into account in operating the CVC investment portfolio and how they differ in the diversity of technical knowledge that can be gained through the operation of this investment portfolio. Finally, in order to create a firm's desired type of innovation (explorative innovation or exploitative innovation), practitioners can get a hint about the impact of CVC operating method (CVC unit's structural autonomy) and firm's internal technological diversity on the type of innovation.

## 6.2 Variable categorization for generating action plan

In sum, using the variables discussed in the three studies of this dissertation paper, corporate investors can create their own action plans that meet their situation and strategic

goals. In order to construct a concrete action plan, it is necessary to classify the variables covered in each study according to their characteristics. Each variable was classified into following three categories; 1) corporate-status variables, 2) corporate-adjustable variables; 3) strategic-objective variables. Corporate-status variables show the technical, financial, and organizational status of the firm at the time of its CVC investment. Corporate investors may have different decisions about which strategic choices and adjustments to take depending on the status of these variables. Corporate-adjustable variables are that corporate investors can control to their situation and goals. Finally, strategic-objective variables include strategic reasons why a firm conducts CVC investments and performance metrics that can be gained from the investments. However, depending on the research model, some of the variables can be both of corporate-status variable and corporate-adjustable variable, or belong to corporate-adjustable variable and the strategic-objective variable. Because of these connected relationship, the variables involved in each study are linked together to form a large-stem decision process. Table 6-1 below shows how the variables of each study are categorized.

First, corporate-status variables include following three variables; 1) *CVC Investor's Absorptive Capacity*, which is used as a moderating variable in Study 1, 2) *Top Management Team Homogeneity* and 3) *Organizational Slack Resource Constraints,* which are used a independent variables of Study 2. *CVC Investor's Absorbent Capacity* (ACAP) is a variable that represents the ability of a firm to assess, acquire and apply the value of new knowledge. It shows the status indicates how well a firm has the ability to understand

and use new knowledge prior to investing in CVC. Moreover, the characteristics of CVC parent firm's TMT members and the size of the organizational slack the firm has are already determined at the time of the CVC investment.

**Table 6-2.** Variable Categories

| Category | Variable | Study |
|---|---|---|
| **Corporate-status variables** | CVC Investor's Absorptive Capacity | Study 1 (moderating variable) |
| | Top Management Team Homogeneity | Study 2 (independent variable) |
| | Organizational Slack Resource Constraints | Study 2 (independent variable) |
| **Corporate-adjustable variables** | CVC Investor's Absorptive Capacity | Study 1 (moderating variable) |
| | CVC Investment Portfolio Diversity | Study 1, 2 (independent & dependent variable) |
| | CVC Dedicated Unit's Structural Autonomy | Study 2, 3 (independent variable) |
| **Strategic-objective variables** | CVC Investor's Technological Diversity | Study 1 (dependent variable) |
| | CVC Investor's Explorative Innovation | Study 3 (dependent variable) |
| | CVC Investor's Exploitative Innovation | Study 3 (dependent variable) |

Next, the variables that can be adjusted through strategic choices include 1) *CVC Investor's Absorbent Capacity (ACAP)* of Study 1, 2) *CVC Investment Portfolio Diversity* of Study 1 and 2, and 3) *CVC Dedicated Unit's Structural Autonomy* and 4) *CVC Investment Stage* of Study 2 and 3. The ACAP of an investment company can be regarded as a status variable as described above, but it can also be regarded as an adjustable variable that can be directly controlled by the corporate investor. In general, a firm's ACAP is measured as the R&D intensity of the corporation in the strategy literatures, and this paper also follows this measurement method (Cohen and Levinthal, 1990; Lin, Wu, Chang, Wang, and Lee, 2012). In other words, ACAP can be classified as a status variable and an adjustable

variable because a firm can choose to increase or decrease the proportion of resources that are strategically invested in R&D activities according to the characteristics of R&D intensity, which is calculated as the ratio of R&D investment to total assets. Next, although *CVC Investment Portfolio Diversity* was used as a dependent variable in Study 2, but it can be seen as part of a firm's investment strategy in general. If a firm wants to acquire knowledge in a various technology areas through CVC investment, it can choose a strategy that increases its portfolio's diversity. *CVC Dedicated Unit's Structural Autonomy* also can be categorized as an adjustable variable because it shows how a corporate investor operate the investment department. The nature of the investment will depend on whether the CVC dedicated department operate independently or if they operate directly under the influence of the parent firm.

Finally, the category of variables that show the corporate investor’s strategic objective include following three variables, 1) *CVC Investor's Technological Diversity* of Study 1, and Study 3’s 2) *CVC Investor's Explorative Innovation* and 3) CVC Investor's Exploitative Innovation. Technological diversity has been used in a number of innovation studies as a status variable or adjustable variable rather than an objective variable. However, many reports and academic papers that conducted surveys of CVC firms and managers show considerable number of respondents said their strategic objective of CVC investment is to broaden the breadth of technological window (MacMillan et al., 2008 – NIST; Dushnitsky et al., 2008 – Ernst & Young; Battistini et al., 2013). In other words, in an environment of high uncertainty, there are many firms that set the strategic goal of CVC investment itself

as increasing the number of technical options that can be utilized in the future. In addition, *Explorative Innovation* and *Exploitative Innovation* can be also regarded as the objective variables because they are representative performance variables in innovation strategy research field.

Thus, by using tables that are grouped according to the characteristics of each variable, firms will be able to select an action plan that is appropriate for their situation and strategic purpose.

## 6.3 Limitations and future research

Despite the contributions and implications the present dissertation provides, it still involves some limitations.

First, some limitations arise from the data used to test the hypotheses. In the dataset of this dissertation, 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 I 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%) in the sample have not applied for patents (yet). Thus this dissertation was 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.

Additionally, as the dataset of this study does not contain firms which did not perform CVC investments, I could not check for different tendencies of innovative activities 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 (RCM; 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. I 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, there is a measurement limitation for firm's innovation performance used in this study. In the data-set, capturing the creation of new technology only form patent application data. Since not every technological innovation is applied for patent, the finding of this study does not account for the creation of non-codified and tacit knowledge (Wadhwa and Kotha, 2006). In addition, sometimes firms are reluctant to disclose their technologies through patents, fearing that imitation by other competitors. Therefore, the

empirical results of this study might underestimate the effect of CVC investment on the firm's innovation activities. I propose future research using other variables such as the development of new products or the creation of non-patent type new knowledge. Moreover, Chapter 3 and 5 have a limitation that it cannot directly count the flow of knowledge from portfolio companies. In these chapters, a new patent applied by corporate investor after CVC investment is regarded as innovation performance through CVC. Of course, while I controlled for some other determinant factors such as internal R&D activities or M&A and alliance experiences that can affect innovation performance of corporate investors, there is a limitation on seeing whether the dependent variables presently have only the effect of CVC investment. If it is possible to use the patent information of the investment target firm to figure out how it is acquired by the corporate investor, it would be a better measurement for the innovation performance of the CVC investment. Future research could collect more detailed samples including patent records of portfolio companies, which would allow me to examine the knowledge flow from the portfolio companies to corporate investors.

Third, some logical limitations arise in interpreting the strategic objectives of CVC investors. Chapter 3 and 4 focus on the search for technology and knowledge in various new areas, a well-known strategic objective of CVC investments. By accessing start-ups in new and diverse technology fields, corporate investors can acquire diversified technology options which allow them to respond to technological paradigm changes in an uncertain environment. The previous survey of MacMillan et al. (2008) found that 65% of companies performing CVC investments are investing not only for financial purposes, but also for

strategic purposes, of which 86% are looking for new technology and business opportunities. These survey results support the significance of the approach of this study. However, some corporate investors are also looking to strengthen their current business model through CVC investments. In Ernst & Young's Global corporate venture capital survey 2008-09', more than half of the corporate investors anticipated that their CVC investments would also contribute to their existing businesses. This survey result implies that many corporate investors expect effects of exploitation as well as exploration through CVC investments, thus they might operate targeted investment portfolios which contribute to their existing businesses instead of diversified portfolios. In other words, corporate investors who initially set the main purpose of CVC investments on strengthening existing business domains may perform specialized investments in limited technology areas, regardless of their organizational characteristics and resource holdings. Moreover, in this case, even if the CVC unit is completely independent from the parent firm, diversified portfolio management may be excluded from the beginning. Chapter 5 attempts to compensate for the limitations in Chapter 3 and 4 by reflecting these investors' perspectives. To complement and justify the premise of the research, i.e., firms are pursuing diversity in their CVC portfolios, I recommend future research to include a survey or other means to examine the investors' perspectives on their CVC investments.

Fourth, in Chapter 4 and 5, the CVC unit's structural autonomy level, which is an independent variable in this study, was measured as a dichotomous variable. In these chapters, autonomy levels were divided according to whether each CVC deal was carried

out as a corporate investor's direct investment or a CVC dedicated subsidiary's independent investment. However, even if a firm conducts CVC investments through an independent subsidiary, there may be cases in which the parent firm's interference is relatively high. On the other hand, it is also possible that relatively more autonomy is given to direct CVC investment through a department located within the organization of corporate investor. Moreover, with this variable, it is difficult to analyze the various dimensions of autonomy given to the CVC unit (e.g., autonomy of decision making, financial resources, and human resources). If future research can develop finer-grained measurement that can reflect various aspects of autonomy, more detailed analyses of the strategic roles of the CVC unit's autonomy will be possible.

In addition, in Chapter 3, there is a coefficient issue about the impact of independent variable on dependent variable. A closer look at the regression results reveals the coefficients for the correlation between two independent variables (Total Amount of CVC Investments and Industrial Diversity of Portfolio Companies) and Dependent Variable (Technological Diversity of CVC Investors). Plotting the graph with the coefficient values of each model shows that the position of the inflection point of the quadratic function composed of the square term is shifted to the left side. In other words, the point of the independent variable's influence on dependent variable is shifted from the positive direction to the negative direction is smaller than the mean value of the independent variable. There are several reasons for this problem. Above all, the number of outliers in the sample is considerably large. In the case of the Industrial Diversity of Portfolio

Companies variable, the sample is distributed from 0 to a maximum of 74.798, but the mean value is only 3.769. These figures mean that a small number of corporate investors operate a highly diversified industry portfolio compared to other investors. Because of the influence of these outliers, when plotting a graph with only two coefficients for an independent variable, a distorted graph can be drawn. Moreover, it should also be taken into account that the influence of other control variables cannot be ruled out. In particular, the control variables such as the Alliance Experience, Cumulative Patent Stock, Firm Size, and Quality of Portfolio Companies are highly correlated with dependent variables, so the graphs that exclude their influence are inevitably distorted.

Finally, in minor point, this dissertation 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 I could not investigate the impact of these characteristics on corporate investors' level of learning from their investment portfolio. I 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, I hope that this dissertation help future researchers in further deepening their understanding of the strategic values and roles of CVC investment as an effective external knowledge sourcing mode.

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# 국 문 초 록

기술적 패러다임의 변화가 급격하며 불확실성이 높은 현대 산업 환경에서는, 어떠한 기술을 개발해야만 미래의 경쟁에서 승리할 수 있을지를 예측하는 것이 매우 어렵다. 특히 이미 상당한 수준의 지식과 자원을 축적해 놓은 기존 기업들의 입장에서 미래의 변화를 대비한 새로운 지식을 창출해 내는 것은 더욱 어려운 일이다. 따라서 기존 기업들은 이러한 한계를 넘기 위해 자신들이 이미 지니고 있는 지식을 활용하는 내부 R&D 전략 뿐만 아니라, 기업 외부의 혁신역량을 습득하기 위한 전략을 병행해야 할 필요성이 높아지고 있다.

특히 최근에는 기술적 잠재력이 높은 신생 벤처기업들로부터 새로운 혁신의 기회를 찾는 기업벤처캐피털이 중요한 전략적 수단으로 부상하고 있다. 기존기업들은 기업벤처캐피털 투자를 통해 익숙하지 않은 새로운 기술분야에 대한 정보나 현재 사업 분야에 활용할 수 있는 기술에 대해 탐색할 수 있다. 또한 투자 이후에는 잠재성이 높은 지식을 보유하고 있는 벤처기업과 전략적 제휴를 형성하거나 M&A를 통한 지식습득을 꾀할 수도 있다. 특히 벤처기업들이 기술혁신의 최첨단을 이끌고 있는 IT산업이나 바이오산업 등에서는 이미 많은 기존기업들이 기업벤처캐피털 투자를 통해 새로운 혁신의 기회를 찾고 있는 상황이며, 이러한 흐름은 전통적인 제조업 분야에도 이어지고 있는 추세이다.

이에 학계에서도 기술혁신전략으로서의 기업벤처캐피털의 역할과 가치에

대해 활발한 연구가 진행되고 있다. 특히 기업벤처캐피털 투자를 한 기업들이 실질적인 기업가치 향상이나 혁신성과 증대와 같은 효과를 누리고 있는지에 대한 실증연구들이 주를 이루고 있으며, 그 밖에도 보다 효율적으로 투자성과를 얻기 위한 투자포트폴리오 관리 연구들도 상당수 진행된 상황이다. 하지만 이러한 기존연구들은 대부분 기업가치나 혁신의 양적인 측면만을 강조하고 있을 뿐, 기업벤처캐피털을 통해 습득할 수 있는 지식의 다양성이나 혁신의 종류와 같은 구체적인 부분을 다루고 있지는 않다. 지식의 다양성은 기존기업이 미래의 환경변화에 유연하게 적응하기 위해 갖추어야 할 필수 덕목이며, 혁신의 종류 역시 기존기업이 기업벤처캐피털 전략을 활용하는 목적성을 반영하는 것이기 때문에 심도 있는 논의가 필요한 영역이다. 따라서 본 논문에서는 이러한 연구의 필요성을 반영하여, 기업벤처캐피털 투자를 통한 기존기업의 '기술적 다양성 증대 효과'와, 이를 위한 '투자포트폴리오 다각화 전략', 그리고 혁신 성과의 방향에 영향을 미칠 수 있는 '투자자율성의 역할'이라는 세 가지 주제를 다룬다.

구체적으로, 본 논문의 제 3장에서는 기업의 '동적 역량' 확대를 위한 '옵션 형성 전략'으로서 기업벤처캐피털이 투자기업의 기술적 다각화에 미치는 영향에 대해 실증 분석했다. 기존기업이 기업벤처캐피털 투자를 하는 전략적인 이유에 대해 논의한 여러 기존 연구들과 관련 설문조사에서는 공통적으로 새로운 지식의 탐색을 통한 기업지식기반의 넓이 증대 효과에 대해 다루고 있다. 즉 기업이 기존에 가지고 있던 지식과는 다른 새로운 지식을 습득함으로써 지식의 다양성을 증대시켜 미래에 활용할 수 있는 기술적 옵션의 가짓수

를 늘리는 전략으로 기업벤처캐피털을 활용한다는 것이다. 하지만 이러한 지식 다각화 효과에 대해 실증적인 분석을 실시한 연구는 드물었다. 이에 본 장에서는 기업벤처캐피털에 투자한 자원의 양과 투자포트폴리오의 산업적 다양성이 이후 투자기업의 기술다각화와 어떠한 상관관계를 갖는지에 대한 실증분석을 실시했다. 1990년부터 2010년 사이에 기업벤처캐피털 투자를 수행한 경험이 있는 미국 내 하이테크 기업들에 대한 실증분석 결과, 기존기업이 기업벤처캐피털에 투자한 자원의 양과 투자포트폴리오의 산업적 다양성은 이들의 기술다각화 성과에 역 유자의 상관관계를 가지는 것으로 나타났다. 또한 기업의 기술적 역량의 관점에서 투자기업이 새로운 지식을 습득하고 이를 소화하여 새로운 혁신을 창출할 수 있는 '흡수역량'이 클수록, 기업벤처캐피털에 대한 투자량과 투자포트폴리오의 다양성이 기술다각화 성과에 미치는 영향을 양의 방향으로 조절한다는 것을 확인할 수 있었다. 이러한 결과는 기업벤처캐피털 투자가 투자기업의 기술다각화를 증대시키는 효과를 가지고 있지만 그 한계가 분명히 존재하기 때문에, 기업은 내부 R&D 활동에도 소홀하지 않음으로써 새로운 지식을 소화하기 위한 흡수역량을 증대하여 이러한 한계를 보완하고자 하는 노력이 필요하다는 제안을 하고 있다.

4장에서는 기업벤처캐피털의 투자포트폴리오 다각화 전략에 대해 보다 구체적으로 살펴보았다. 기존기업이 기업벤처캐피털을 통해 다양한 외부 지식풀에 접근하기 위해서는, 기본적으로 다양한 기술 및 산업 분야에 종사하고 있는 벤처기업들로 구성된 다각화된 투자포트폴리오를 구성해야 한다. 하지만 실제로 기업벤처캐피털 투자를 수행하는 기업들을 살펴보면 다각화된 포트폴

리오를 운영하는 기업들도 있지만, 소수의 특정 기술분야에만 집중된 투자를 하고 있는 기업들도 존재한다는 것을 알 수 있다. 본 연구에서는 이처럼 기업벤처캐피털을 수행하는 기업들 마다 투자포트폴리오의 다각화 정도가 다른 이유를 이들이 지니고 있는 '경영적 관심'의 차이에서 찾고, 이러한 경영적 관심에 영향을 미칠 수 있는 세가지 조직적 결정요인들로 '모기업 임원진의 동질성', '조직적 여유 자원의 부족', '투자전담부서에 부여되는 구조적 자율성'의 역할에 대해 실증분석을 실시했다. 그 결과, 모기업의 임원진이 서로 유사한 경험을 지닌 인원들로 구성된 경우와 기업 조직 내 여유 자원이 부족한 경우에는 투자기업이 비교적 다각화 되지 않은 투자포트폴리오를 운영하는 것을 확인할 수 있었다. 반면, 기업벤처캐피털 투자를 전담하는 부서에 부여되는 구조적 자율성의 크기가 클수록, 보다 더 다각화된 투자포트폴리오를 운영할 수 있게 된다는 것을 실증적으로 확인할 수 있었다. 이러한 결과를 통해 만약 기업벤처캐피털 투자를 기획하는 기업이 보다 다양한 지식 풀로의 접근을 원한다면, 전략적으로 동질화 된 관심을 가지고 있는 임원진들의 간섭과 투자의 우선순위를 형성하도록 유도하는 자원적 제약에서 벗어나, 투자 전담부서가 보다 자유로운 투자 선택을 할 수 있도록 구조적 자율성을 보장해주는 것이 효과적이라는 것을 알 수 있다.

하지만 이러한 구조적 자율성은 기존기업이 기업벤처투자를 통해 얻고자 하는 혁신의 종류에 따라 때때로 다른 역할을 할 가능성이 존재한다. 구조적 자율성을 부여 받아 자유롭고 모험적인 투자성향을 가지게 되는 것이 항상 원하는 방향의 혁신성과로 이어지지는 않을 수 있기 때문이다. 기업벤처캐피털

을 수행하는 기존기업들 중에는 앞서 논의했던 바와 같이 미래에 활용할 수 있는 새로운 지식과 사업 기회를 탐색하는데 주 목적을 가지고 있는 기업들이 있는가 하면, 자신들의 현재 사업 영역을 강화시키기 위한 지식을 습득하는데 주 목적을 가지고 있는 기업들 역시 존재할 수 있기 때문이다. 이에 본 논문의 제 5장에서는 기업벤처캐피털 투자 전담 부서에 부여되는 구조적 자율성과 투자 모기업이 지니고 있는 내부 기술지식의 다양성이 '양손잡이전략'에서 이야기 하는 '활용'과 '탐색'이라는 두 가지 측면의 혁신활동에 각각 어떠한 영향을 미치는지에 대해 실증 분석하였다. 분석결과, 구조적 자율성을 부여받은 기업벤처캐피털 투자 전담 부서는 다양한 기술 분야에 대한 자유로운 투자를 통해 '탐색적 혁신활동'에 긍정적인 성과를 얻고 있음을 확인할 수 있었다. 반면 이러한 구조적 자율성은 역설적으로 모기업이 오랜 기간 축적해 놓은 기술지식과 전문화된 인적자원으로부터의 단절을 의미하므로, 새롭게 습득한 지식과 기존지식의 결합을 통해 새로운 혁신을 재창조해야 하는 '활용적 혁신활동'에는 부정적인 영향을 미친다는 것을 알 수 있었다. 또한 투자 모기업이 지니고 있는 내부 지식의 기술적 다양성은 '탐색적 혁신활동'과 '활용적 혁신활동' 모두에 긍정적인 상관관계를 가지고 있는 것으로 나타났다. 따라서 기업벤처캐피털 투자를 하고자 하는 기업들은 자신들이 얻고자 하는 투자 성과의 종류를 명확하게 설정함으로써 투자 전담 부서를 어떠한 방식으로 운영해야 할지를 결정해야만 원하는 방향으로의 혁신성과를 얻을 수 있을 것이다.

결론적으로 본 논문은 외부지식습득을 위한 기업벤처캐피털 투자의 역할에

대해 다루고 있으며, 특히 기술지식다각화 전략으로서의 가치와 이를 위한 전략적 선행 요소들, 그리고 혁신의 종류에 따른 투자 전담 부서의 운영 방식에 대한 연구에 기여하고 있음을 밝힌다. 기업벤처캐피털 투자의 전략적 활용에 대한 본 논문의 주요 결과와 의의는 다음과 같다. 첫째, 본 논문은 비과학적인 의사결정 요인들이 많이 작용하게 되는 기업벤처캐피털 투자의 전략적인 이슈들을 학문적인 프레임워크로 재해석함으로써 학계 발전에 기여하고 있다. 둘째, 본 논문은 기업벤처캐피털 투자가 투자기업의 기술지식다각화에 미치는 영향을 확인하고 이러한 다각화 효과를 증대시키기 위한 방안으로서 기업의 흡수역량의 중요성에 대해 강조하고 있다. 다음으로 본 논문은 기업벤처캐피털을 수행하는 기업들이 다각화된 투자포트폴리오를 구성하여 보다 다양한 외부 지식 풀에 접근하기 위해서는, 모기업 임원진들의 전략적 개입과 자원적 제약으로부터 벗어난 독립적인 투자활동을 위해 구조적 자율성이 보장된 투자 전담 부서를 운영해야 함을 밝히고 있다. 마지막으로 이러한 구조적 자율성은 기업벤처캐피털 투자를 통해 기업이 얻을 수 있는 혁신 성과 중 탐색적 혁신에 대한 성과에는 도움을 주지만 활용적 혁신에는 부정적인 영향을 미친다는 것을 확인함으로써, 기업의 전략적 목적성에 따라 투자 전담 부서의 운영 방식을 달리 해야 한다는 것을 권고하고 있다. 정리하면, 본 논문은 기존기업들이 기업벤처캐피털 투자를 통해 다양한 방식의 혁신성과를 도출할 수 있으며, 자신들이 원하는 방향으로의 혁신성과를 얻기 위해서는 목적성에 맞는 적절한 투자전략을 수행하는 것이 가장 중요하다는 것을 강조하고 있다.

**주요어 : 기업벤처캐피털; 외부지식습득전략; 기술다각화; 흡수역량; 투자포트폴리오; 구조적 자율성; 탐색적 혁신과 활용적 혁신**

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