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The double-edged effects of the corporate venture capital unit's structural autonomy on corporate investors' explorative and exploitative innovation

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ABSTRACT

Although most prior literature on the strategic value of corporate venture capital (CVC) investments has focused solely on its role as an explorative learning method, in reality, many corporate investors are also using CVC investments for exploitative learning to strengthen their existing business model. In this study, we focus on the operational aspects of CVC investments and discuss how the explorative and exploitative innovation performance of corporate investors is affected by the level of the structural autonomy granted to their CVC dedicated unit. Using 20 years of panel data from 77 corporate investors in U.S. high-tech industries, we find that the structural autonomy of the CVC unit exhibits a positive relationship with the corporate investor's explorative innovation performance, while it is negatively related with exploitative innovation performance.

1. Introduction

In order for incumbent firms to adapt to the modern market environment of rapid and radical shifts of the technological paradigms, dynamic capabilities are required to acquire valuable knowledge from outside the firm and to integrate it with internal knowledge (Teece, Pisano, & Shuen, 1997). Many scholars argue that in order to possess such dynamic capabilities, it is necessary to employ external knowledge sourcing strategies such as strategic mergers, strategic alliances, or joint ventures with other firms that possess useful knowledge as well as to utilize the firm's internal R&D (Schildt, Maula, & Keil, 2005; Van de Vrande & Vanhaverbeke, 2013). In recent years, corporate venture capital (CVC) investment has been recognized as a very useful strategy for incumbent firms to develop dynamic capabilities (Dushnitsky & Lenox, 2005; Lee & Kang, 2015).

CVC investment refers to incumbent firms making small equity investments in start-ups with good technological potential (Gompers & Lerner, 2000). CVC investment conducted by a non-financial firm is different from a general venture capital (independent venture capital, IVC) investment. As CVC investments are conducted by non-financial firms, in addition to any financial objectives, these deals are often conducted for strategic purposes such as finding new business opportunities or acquiring valuable knowledge from investment target companies (Block & MacMillan, 1993). Specifically, in terms of innovation strategy, CVC investment is characterized by pursuing both exploration and exploitation (Hill & Birkinshaw, 2014): exploration serves to search and acquire unfamiliar and novel technologies and resources and aims to generate variation, while exploitation focuses mainly on the enhancement of the efficiency and productivity of the firm's activities through refinement and extension of existing competencies and technologies (March, 1991).

Until now, the majority of studies on the relationship between CVC investments and corporate investors' innovation performance have focused on explorative innovation performance (Basu, Phelps, & Kotha, 2011; Burgelman, 1983; Dushnitsky & Lenox, 2006; Kanter, 1985; Wadhwa & Kotha, 2006). However, as Hill and Birkinshaw (2014) have shown, many corporate investors pursue exploitative innovations in technological areas that are closely related to their current businesses. Indeed, some survey results such as NIST's (National Institute of Standards and Technology) CVC report[1] and the Ernst & Young Global Corporate Venture Capital Survey[2] support this argument. According to the survey results, many respondents identified both "providing window on new technology" and "supporting existing business" as the most important strategic objectives of their CVC investments.

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[2] Dushnitsky, G., Haemming M., and Tharp. D. (2008). Global Corporate Venture Capital Survey 2008–09: Benchmarking Programs and Practices. *Supported by Ernst & Young.*

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Moreover, some academic studies based on in-depth interviews, e.g., Battistini, Hacklin, and Baschera (2013) and Markham, Gentry, Hume, Ramachandran, and Kingon (2005), also addressed that corporate investors pursue both explorative and exploitative learning purposes. In other words, since the strategic direction of each corporate investor is different, the types of innovation outcome they create through CVC investments can also be different. In order to achieve the desired innovation outcome more efficiently, corporate investors need to choose an appropriate method of operating their investment organization.

In this vein, we examine the relationship between the operational aspects of CVC investments and two different perspectives of innovative performance: exploration and exploitation. In particular, from an organizational standpoint, we focus on the structural autonomy of the CVC unit, which has a significant impact on the operating process of CVC investments (Gompers & Lerner, 2001; Siegel, Siegel, & MacMillan, 1988; Yang, Chen, & Zhang, 2016). The CVC unit's structural autonomy allows the managers to be dedicated to CVC investments and enables them to perform autonomous investments by freeing them from the strategic attention of their parent firm (Yang et al., 2016). Since autonomous CVC units tends to respond aggressively to investment in different opportunities with minimal corporate interferences, they can operate more as a diversified portfolio and take more risks in adventurous investments in unfamiliar technology areas (Siegel et al., 1988). Due to this specificity of the investment process, we argue that the structural autonomy will have different impacts on explorative and exploitative innovation through CVC investments. An autonomous CVC's free investment activities and diverse portfolio can be helpful for exploring new technology areas. On the other hand, in exploitation aiming at enhancing 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 its accumulated technological knowledge and network resources. Therefore, we hypothesize that the degree of structural autonomy of the CVC unit will increase the corporate investor's explorative innovation performance, but will have a negative effect on the exploitative innovation performance.

Empirically, we analyzed an unbalanced panel of U.S. high-tech firms that performed CVC investments during the time period of 1990 to 2010. Through this empirical analysis we find an increase in the degree of structural autonomy of the CVC unit is associated with a subsequent increase in the number of newly applied patents and their forward citations in explorative technology areas, while it is negatively related with the number of applied patents and forward citations in exploitative technology areas.

This paper makes contribution to the growing literature on the relationship between CVC investments and the firm's innovation performance. Unlike previous studies, which focused solely on the innovative value of CVC investments as a window on new technologies, we examine both perspectives of innovation, exploration and exploitation. Further, this research contributes to the research on organizational behavior, specifically on the structural autonomy of the CVC unit. Finally, this study provides managerial implications by providing insights into how the CVC unit should be structured and operated in accordance with the corporate investor's strategic objectives.

2. Theory and hypotheses

2.1. Exploration, exploitation, and CVC

Many studies on strategic management and organization theory have employed 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 knowledge that is new to the firm. 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, it allows organizations to create more radical innovations (Rosenkopf & Nerkar, 2001). 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's ongoing activities. These properties make exploitation relatively fast, efficient and predictable in terms of performance, however, it tends to be limited to short-term gradual innovation (Duncan, 1976; Eisenhardt & Martin, 2000; Levinthal & March, 1993; March, 1991; Tushman & O'Reilly, 1996).

Since establishment of the concept of exploration and exploitation, research has been actively conducted on what is referred to as ambidexterity strategy, in which firms pursue both short-term survival and long-term growth by combining these two organizational learning activities (He & Wong, 2004; Hoang & Rothaermel, 2010; Lavie, Kang, & Rosenkopf, 2011; Lavie, Stettner, & Tushman, 2010; Raisch & Birkinshaw, 2008; Stettner & Lavie, 2014). 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 the other departments primarily focusing on exploitation-oriented activities (e.g., manufacturing plants or sales forces) (Hill & Birkinshaw, 2014). Temporal separation, on the other hand, refers to firms undertaking exploration and exploitation at different times (Puranam, Singh, & Zollo, 2006).

In general, prior studies on CVC investment consider the CVC unit as a separated department for explorative learning. Although this study also sees the CVC unit as a separated department for the incumbent firm's external searching activities, we argue that the CVC unit's activities are not only limited to exploration, but that it also conducts exploitative learning activities (Campbell, Birkinshaw, Morrison, & van Basten Batenburg, 2003; Hill & Birkinshaw, 2008, 2014; Keil, Maula, Schildt, & Zahra, 2008; Schildt et al., 2005). Indeed, some corporate investors are pursuing both explorative and exploitative innovations through their CVC units. For example, the case of Samsung Electronics, one of the world's largest electronics manufacturers, reveals the tendency of these investment patterns. Samsung Electronics is both investing in start-ups that possess technologies that are not related to Samsung's current business areas, such as food and bio-health care technologies, as well as in companies that possess technologies that can directly contribute to Samsung's core products, such as voice recognition technology that can be used in Samsung smartphones. Moreover, also Intel, a worldwide developer of microprocessors, manages a diversified investment portfolio that includes start-ups in unrelated industries to prepare for future change, while also investing heavily in startups in related industries to improve the performance of their core businesses.

Thus, in order to better understand innovation strategy through CVC investment, it is necessary to consider and analyze both the explorative and exploitative nature of CVC. In particular, this paper examines the role of structural autonomy in terms of the operation of the CVC dedicated unit because the direction of the innovation output resulting from the CVC investment may depend on how firms structure and operate their CVC activities.

2.2. Structural autonomy of the 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 are under tight control from the parent firm when selecting investment targets, while some other CVC units are wholly owned subsidiaries that operate completely independent from the parent firm's control (Gompers & Lerner, 2001; Siegel et al., 1988).

A number of previous studies have suggested that CVC units should be given more autonomy to improve the strategic performance of the 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 the boundaries of the different possibilities (or opportunities), and making high-risk investments from time to time. (Simon, Houghton, & Gurney, 1999). In order to pursue such adventurous and aggressive investment decisions, the CVC unit must operate independently of the parent firm.

A CVC unit that 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 such CVC units 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 & Hill, 2005). The autonomous CVC unit can make investment decisions, even if the target companies that the CVC unit intends to invest in has, in the short run, no apparent contribution to the current business model of the parent firm (Chesbrough, 2002; Siegel et al., 1988; Yang et al., 2016). It also creates the potential for investment in which the start-up investment targets are potential competitors for the firm's existing business units.

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 parent firm's current strategic interests. Since this independent CVC unit typically establishes separate fund pools, it can be free from restrictions on investments due to a situation of insufficient resources of the parent company (Birkinshaw & Hill, 2005). As a result, an independent CVC unit can pursue adventurous and aggressive investment decisions aiming at long-term advantages while leading to more variance performance.

GV (formerly known as Google Ventures), a subsidiary of Google, is a typical example of this concept of independent CVC. GV's main investment objective is to explore new markets. GV has invested in disruptive innovations that have escaped existing trends and invested in a variety of technologies that are of little relevance to each other, but allow broadening the 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, a startup possessing mobile OS development technology. Recently, GV continues to invest in new and diverse technology areas, including mobile, internet, and software technologies, as well as renewable energy, bio-health care, and organic agricultural products. GV can operate this adventurous exploratory investment portfolio as it has been granted almost complete investment autonomy from Google.

In summary, since structurally autonomous CVC units can operate their investment portfolio independent from the parent firms' strategic interests, they can conduct more explorative investment for the long-term advantages. This point of view results in the following hypothesis:

Hypothesis 1. The level of structural autonomy of the CVC unit has a positive relationship with the corporate investor's explorative innovation performance.

2.3. Structural autonomy of the CVC unit and exploitation

Gupta, Smith, and Shalley (2006, p.696) point out that "the learning, resources, and routines necessary for exploration and exploitation are different". Similarly, for CVC investments, the way of operation that is more conducive to exploitation may be different from what is advisable for the case of exploration. 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, more than anything else, it is important to use the valuable resources, such as high-quality technical knowledge and skilled experts that they have accumulated over time (Hoang & Rothaermel, 2010; March, 1991). In other words, in order to make exploitative learning more efficient, it is best to place the CVC unit inside the parent firm so that it can cooperate closely with other business units.

The case of Cisco, the leader in the network equipment market, is a good example. Cisco is investing in CVC through Cisco Investments, which is a part of the Cisco Corporate Strategy Office. The investment objective of the Cisco Corporate Strategy Office is not to search for various new technological fields, but to specifically search for M&A targets that have the necessary technology needed by the parent company. When deciding on CVC investments, Cisco prioritizes how well the technology and vision of the investee match its own. In addition, Cisco focuses on how quickly it can generate revenue through the newly acquired technological knowledge from its 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 tends to focus on immediate strategic gains rather than pursuing adventures in new technology areas. Looking at Cisco's recent investment portfolio, we can see that it is composed of big data, cloud computing, and IoT-related start-ups that in one way or the other relate to Cisco's existing network technology.

On the other hand, 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 the CVC unit in finding target companies which possess compatible knowledge that can effectively complement the parent firm's existing knowledge (Hill & 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 the parent firm who can fully understand and use the acquired knowledge of target firm (Carnabuci & Operti, 2013; Cohen & Levinthal, 1990).

Therefore, although an 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 from the parent firm's valuable cumulative resource. From this perspective, we present the following hypothesis:

Hypothesis 2. The level of structural autonomy of the CVC unit has a negative relationship with the corporate investor's exploitative innovation performance.

3. Methods and modeling

3.1. Data and sample

The empirical analysis is based on a sample of U.S. high-tech firms which have conducted CVC investments during the period from 1990 to 2010. Generally, since the rate of technology changes are faster in high-tech industries compared to low-tech industries, we believe firms operating in high-tech sectors will be more likely to incentivize CVC investments.

We follow the classification of the high-tech industries provided by the Securities Data Company (SDC) Platinum Database. According to this industry classification 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'. Next, we collected our sample of corporate investors from the ThomsonOne.com PE/VC Module Database which contains the same information as VentureXpert, a tool extensively used in prior studies on VC. The ThomsonOne.com PE/VC Module Database provides a list of CVCs and data on each investment round. Since many investor firms established wholly owned subsidiaries (structurally autonomous units) or independent funds for their CVC investments, we had to search for the name of the subsidiaries and funds in online databases such as Lexis-Nexis DB to link them with their corporate parents.

Moreover, to investigate the corporate investors' innovation performance, the study uses patenting data provided by the U.S. Patents and Trademarks Office (USPTO) database, specifically the number of applied patents and their forward citations. For identifying the corporate investors' patent classes, the International Patent Classification (IPC)'s 3-digit code was used. 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 the data and removing samples that have missing data, the finalized panel consists of 318 firm-year observations with 77 sample firms.

3.2. Measures

3.2.1. Dependent variables

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

In particular, Wadhwa and Kotha (2006) used the primary technology class (3-digit patent class code) of a corporate investor's patents to estimate the firm's innovative performance in specific technology areas. Our study follows this approach by estimating whether the technology classes of the newly applied patents subsequent to the CVC investments are overlapped with the patent classes of the corporate investor's existing patents or not. In other words, if the newly applied patent belongs to a primary technology classes in which the corporate investor had already been actively patenting its innovations, this is considered as exploitative innovation output. On the other hand, if the newly applied patent belongs to a new-to-the-firm primary technology class, i.e., a class which is not in the corporate investor's patent class pool, this is regarded as explorative innovation. Therefore, we counted the number of applied patents in the corporate investor's existing technology classes as *Exploitative Innovation Performance*, and the number of applied patents in new-to-the-firm technology classes as *Explorative Innovation Performance*. Further, we counted the forward citations of the applied patents to examine the qualitative aspects of the newly created inventions. The analysis of this quality of innovation is discussed in detail in the section of this study explaining our conducted robustness test.

However, since the application for 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 actually the results of prior R&D efforts (Hausman, Hall, & Griliches, 1984). To overcome this limitation, we use a cumulative lagged dependent variable of patent application data covering a 3-year time span from year t to year t + 2. Using such a cumulative lagged dependent variable allows us to enhance the demonstration of the temporal order of cause and effect.

3.2.2. Independent variable

The independent variable of this study is the *CVC Unit's Structural Autonomy*. Most prior studies measured the structural autonomy of CVC unit using survey data (Birkinshaw & Hill, 2005; Hill & Birkinshaw, 2008). However, more recent research, e.g., Yang et al. (2016) and Kang and Park (2015), working paper) used archival data collected from electronic databases.

Yang et al. (2016) classified CVC programs into two categories in the VentureXpert database: 1) an internal program with direct investment from the 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 the investment process because this kind of investment can be closely aligned with the 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 as a structurally independent subsidiary gives CVC managers greater autonomy to manage the investment activities. Thus, the authors create 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 investments undertaken by an independent CVC subsidiary, and the value 0 was assigned to internal CVC programs' direct investments.

This study follows Yang et al. (2016) and Kang and Park's (2015) approach to measure the CVC unit's structural autonomy. As a result, in our panel, a corporate investor's annual CVC structural autonomy level is measured by the average value of each investment's structural autonomy, leading to a variable whose value falls between 1 and 0 (Fig. 1).

3.2.3. Control variables

In addition to the independent variable, there are other factors that can affect a corporate investor's innovation performance. We controlled for the corporate investor's size based on its total sales because larger firms may have more resources to generate innovative outputs. Moreover, we controlled for the firms' R&D expenditure because it can represent the engagement of a firm in innovative activities. Therefore, we controlled for the natural log of firm i's total sales and total R&D expenditure in year t − 1 as a proxy for firm size and R&D expenditure and also controlled for the technological diversity of the parent firm.

At the strategy level, we controlled for the firms' 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. Furthermore, at the CVC program level, we controlled for the amount of CVC investment, the number of industries in the CVC portfolio, and the number of co-investors to investigate the quality of portfolio companies (Wadhwa & Kotha, 2006). Finally, a fixed effect of the industry was also controlled for, because the level and pattern of innovation performance might be different among the various industries in our sample.

3.3. Statistical method

Explorative Innovation Performances 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 take negative values. Thus, we decided to use a negative binomial regression model which is one of the nonlinear models commonly used to avoid heteroscedasticity problems (Hausman et al., 1984; Wadhwa & 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 our dependent variables (9.538 for explorative performance, and 669.217 for exploitative performance) are larger than their mean values (9.519 and 466.182), we chose the negative binomial

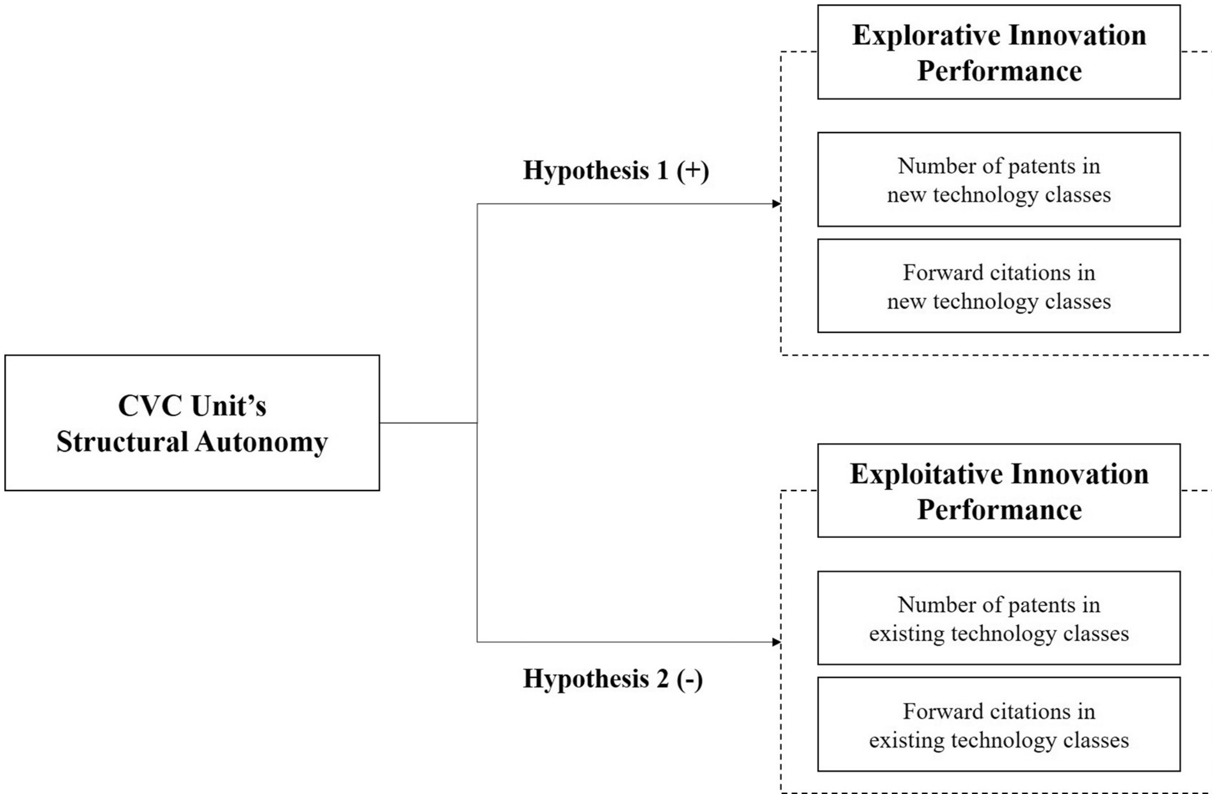

Fig. 1. Conceptual diagram.

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, we conducted a Hausman test (Hausman et al., 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 our panel data.

4. Results

4.1. Descriptive statistics and correlations

Table 1 presents the descriptive statistics of the two dependent variables, the independent variables, and the control variables used in our study as well as the correlations between them. The average of the dependent variable *Explorative Innovation Performance* is 9.519, and of the dependent variable *Exploitative Innovation Performance* is 466.182. We can observe that most of the newly applied patents fall within the corporate investors' existing technology areas. With regard to the structural autonomy of the CVC unit, about 59.4% of the CVC deals in the sample were undertaken by structurally independent CVC units.

The correlations between the variables of this study show that the firms' previous M&A experience is highly correlated with their strategic alliance experience (correlation factor: 0.603). In addition, other control variables such as the number of industries in the CVC portfolio and the number of co-investors are highly correlated (correlation factor: 0.863). These high correlations could lead to a multicollinearity problem in the process of regression. In order to check for the presence of any multicollinearity problem, we additionally performed a Variance Inflation Factor (VIF) test. The low VIF test result values (average of 2.36, maximum of 5.47) indicate that our sample does not have any problem with multicollinearity. Moreover, although two independent variables of exploitative innovation performance (number of newly applied patents and number of forward citations in existing technology classes) are highly correlated (correlation factor: 0.846), this correlation does not affect the regression results because these two variables are not included in the same regression models.

4.2. Regression results

Table 2 shows the results of the random effects negative binomial regression model. Model 1 and Model 3 are the unconstrained models which include only the control variables on the condition of excluding the independent variables. The dependent variable of Model 1 is the corporate investors' *Explorative Innovation Performance.* In Model 1, the coefficients of *Firm Size* and *Technological Diversity* are significant, i.e., we find that large firms as well as firms which have a strongly diversified technological pool tend to generate more patents in new technology areas. In Model 3, which takes the corporate investors' *Exploitative Innovation Performance* as a dependent variable, the variable of *Technological Diversity* also shows a positive and significant coefficient.

Model 2 and Model 4 additionally include the *CVC Unit's Structural Autonomy* to test our Hypotheses 1 and 2. Hypothesis 1 predicts a positive relationship between the structural autonomy of the CVC unit and the corporate investor's explorative innovation. In Model 2, we find a positive and statistically significant relationship between the CVC Unit's Structural Autonomy and the corporate investor's explorative innovation (b = 0.330, $p < 0.01$), which is consistent with our Hypothesis 1.

Hypothesis 2 predicts a negative relationship between the structural autonomy of the CVC unit and corporate investor's exploitative innovation. In our opinion, highly autonomous CVC units will have a negative impact on exploitative innovation due to them being disconnected from the parent firm's valuable resources such as professional expertise, accumulated technology, tacit knowhow, and networks. In Model 4, the coefficient of structural autonomy of the CVC

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Table 1
Descriptive statistics and correlations.

	Variable	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Explorative Innovation Performance (t to t + 2) (number of patents in new technology classes)	9.519	9.538	1	84	1.000												
2	Exploitative Innovation Performance (t to t + 2) (Number of patents in existing technology classes)	466.182	669.217	1	4063	0.430	1.000											
3	Explorative Innovation Performance (t to t + 2) (Forward citations in new technology classes)	20.116	31.774	0	250	0.598	0.296	1.000										
4	Exploitative Innovation Performance (t to t + 2) (Forward citations in existing technology classes)	1159.258	2116.136	0	14,556	0.340	0.846	0.399	1.000									
5	CVC unit's structural autonomy (t − 1)	0.594	0.476	0	1	0.325	−0.013	0.218	−0.049	1.000								
6	Firm size (t − 1)	9.110	1.866	1.366	12.106	0.422	0.474	0.205	0.337	0.380	1.000							
7	R&D expenditure (t − 1)	6.455	1.964	0	9.106	0.324	0.475	0.144	0.320	0.049	0.534	1.000						
8	M&A experiences (t − 1)	4.686	5.451	0	44	0.145	0.399	0.172	0.491	−0.019	0.343	0.279	1.000					
9	Alliance experiences (t − 1)	6.296	10.736	0	97	0.085	0.553	0.187	0.681	−0.089	0.287	0.251	0.603	1.000				
10	Technology diversity (t − 1)	0.814	0.176	0	0.980	0.441	0.417	0.271	0.329	0.165	0.447	0.252	0.209	0.201	1.000			
11	Amount of CVC investment (t − 1)	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 (t − 1)	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 (t − 1)	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

unit is negative and statistically significant ($b = -0.257$, $p < 0.05$), which is consistent with our Hypothesis 2.

4.3. Robustness test

To further improve the robustness of our empirical results, we additionally performed a regression analysis using an alternative measure for our dependent variable. Specifically, we used the corporate investor patents' forward citation data as an alternative measurement of innovation performance. The use of the citation information has the advantage of being able to measure not only quantitative but also qualitative aspect of innovation performance at the same time (Dushnitsky & Lenox, 2005; Hagedoorn & Cloodt, 2003; Trajtenberg, 1990). For this reason, patent citations are commonly used in recent studies to measure the firm's innovation performance.

Table 3 shows the full results of the additional regression analysis based on the corporate investors' received patent citations. We find that the CVC unit's structural autonomy has a positive and statistically significant relationship with the corporate investor's patent citations in newly generated technology areas (exploration), while it has a negative and statistically significant relationship with the patent citations in existing technology areas (exploitation). These results are in line with the main analysis results using the number of applied patents. This adds further support to our hypotheses, as they can be regarded as robust for both the quantitative and qualitative dimensions of innovation performance.

5. Discussion and conclusion

This research sheds light on the argument that the direction of the innovation achieved by the corporate investor may vary depending on how the CVC investment is organized and operated. More specifically, we investigate the effect of the CVC unit's structural autonomy on the corporate investor's innovation performance in two key aspects: exploration and exploitation. We examine the effect of the CVC unit's structural autonomy as an accelerator of the corporate investor's explorative innovation due to performing relatively unconstrained and adventurous investments. On the other hand, in the case of exploitative innovation, we analyze the role of structural autonomy as an inhibitor due to the disconnection between the CVC unit and the parent firm's valuable resources. We analyzed empirical data of U.S. high-tech firms that have performed CVC investments and the results of this empirical analysis support our hypotheses. We further increased the quality of our empirical results through a robustness test focusing on qualitative aspects of the parent firm's innovation performance, specifically their patenting quality as measured by the number of forward citations.

5.1. Contributions

This paper provides some valuable insights contributing to several streams of literature. First, this study provides a detailed understanding of role of CVC investments as an innovation strategy by considering both explorative and exploitative innovation performance. While previous literature has acknowledged the relationship between CVC investments and the corporate investor's innovation performance, most studies focused solely on the CVC's boundary-spanning function to capture new business opportunities and technological discontinuities (Maula, Keil, & Zahra, 2013). Unlike these previous studies, this study reexamines the role of CVC investment also as an exploitative learning method that can strengthen the existing businesses of the corporate investors. Indeed, as evidenced in a previous survey, many corporate investors indicated that they pursue both explorative and exploitative innovation. In order to better understand the strategic behavior of practitioners conducting such CVC investments, it is desirable to review investment strategies for both exploration and exploitation.

Second, this study also provides a more detailed understanding of

Table 2
Random effect negative binomial regression models for number of applied patents in t to t + 2.

Variables	Explorative Innovation Performance (Number of patents in new technology classes, t to t + 2)				Exploitative Innovation Performance (Number of patents in existing technology classes, t to t + 2))			
	Model 1		Model 2		Model 3		Model 4	
Independent variable								
CVC unit's structural autonomy$_{(t-1)}$			0.330**	(0.118)			−0.257*	(0.123)
Control variables								
Firm size$_{(t-1)}$	0.127**	(0.040)	0.0820*	(0.041)	−0.001	(0.054)	0.034	(0.056)
R&D expenditure$_{(t-1)}$	−0.024	(0.037)	0.000	(0.037)	0.046	(0.058)	0.035	(0.057)
M&A experiences$_{(t-1)}$	0.011	(0.008)	0.012	(0.008)	0.012	(0.007)	0.012	(0.007)
Alliance experiences$_{(t-1)}$	−0.005	(0.004)	−0.004	(0.004)	0.001	(0.004)	0.000	(0.004)
Technology diversity$_{(t-1)}$	1.923***	(0.411)	2.135***	(0.405)	3.498***	(0.514)	3.183***	(0.531)
Amount of CVC investment$_{(t-1)}$	−0.044	(0.026)	−0.047	(0.025)	−0.023	(0.025)	−0.016	(0.026)
Number of CVC portfolio industry$_{(t-1)}$	0.014	(0.010)	0.014	(0.009)	0.000	(0.008)	0.000	(0.008)
Quality of portfolio companies$_{(t-1)}$	−0.001	(0.000)	−0.001	(0.000)	0.000	(0.000)	0.000	(0.000)
Industry dummies	Yes		Yes		Yes		Yes	
Constant	−1.467**	(0.554)	−1.502**	(0.534)	−2.704***	(0.782)	−2.590***	(0.777)
ln_r_cons	2.318***	(0.276)	2.490***	(0.291)	−0.178	(0.200)	−0.142	(0.204)
ln_s_cons	2.554***	(0.334)	2.735***	(0.345)	2.679***	(0.422)	2.753***	(0.430)
N	318		318		318		318	
Log likelihood	−915.792		−911.954		−1974.244		−1972.032	
Wald χ^2	84.95*** (0.000)		100.85*** (0.000)		105.80*** (0.000)		116.55*** (0.000)	

n = 318.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 3
Robustness Test - random effect negative binomial regression models for forward citations of applied patent in t to t + 2.

Variables	Explorative Innovation Performance (Forward citations in new technology classes, t to t + 2))				Exploitative Innovation Performance (Forward citations in existing technology classes, t to t + 2))			
	Model 5		Model 6		Model 7		Model 8	
Independent variable								
CVC unit's structural autonomy$_{(t-1)}$			0.320*	(0.158)			−0.418**	(0.162)
Control variables								
Firm size$_{(t-1)}$	0.060	(0.045)	0.017	(0.049)	−0.091	(0.055)	−0.029	(0.059)
R&D expenditure$_{(t-1)}$	−0.075	(0.043)	−0.052	(0.044)	0.014	(0.055)	−0.009	(0.054)
M&A experiences$_{(t-1)}$	−0.002	(0.012)	0.000	(0.013)	0.009	(0.011)	0.008	(0.011)
Alliance experiences$_{(t-1)}$	0.010	(0.005)	0.011	(0.006)	0.015**	(0.005)	0.014**	(0.005)
Technology diversity$_{(t-1)}$	1.960***	(0.530)	2.145***	(0.529)	2.431***	(0.542)	2.098***	(0.554)
Amount of CVC investment$_{(t-1)}$	−0.060	(0.043)	−0.071	(0.043)	−0.033	(0.040)	−0.025	(0.040)
Number of CVC portfolio industry$_{(t-1)}$	0.027	(0.018)	0.028	(0.018)	0.017	(0.015)	0.015	(0.015)
Quality of portfolio companies$_{(t-1)}$	−0.001	(0.001)	−0.001	(0.001)	0.000	(0.000)	0.000	(0.000)
Industry dummies	Yes		Yes		Yes		Yes	
Constant	−2.205***	(0.597)	−2.212***	(0.586)	−1.923*	(0.782)	−1.905*	(0.773)
ln_r_cons	1.472***	(0.368)	1.637***	(0.397)	−0.272	(0.251)	0.201	(0.255)
ln_s_cons	4.431***	(0.478)	4.628***	(0.501)	4.494***	(0.612)	4.656***	(0.603)
N	318		318		318		318	
Log likelihood	−1185.972		−1183.944		−2271.785		−2268.549	
Wald χ^2	55.59*** (0.000)		61.17*** (0.000)		89.38*** (0.000)		100.27*** (0.000)	

n = 318.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

the organizational operation of CVC investments. Specifically, we focus on the role of the structural autonomy of the CVC unit. Previously, several studies have discussed the strategic value of the structural autonomy given to the CVC unit. Siegel et al. (1988) argued that an autonomous CVC unit, which is entrusted with full authority over the investment from the parent firm, can enjoy a 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 units can be free from restrictions of the parent firm's insufficient resource situation because they usually establish a separate fund pool. Recently, Yang et al. (2016) showed that the structural autonomy of a CVC program is significantly related to its investment portfolio diversification. However, there is a lack of studies that classify the impact of the CVC's structural autonomy on the explorative and exploitative innovation of the corporate investor. This study aims at highlighting how to operate a CVC unit efficiently by carefully examining the role of structural autonomy, which influences decision-making processes before the investment as well as the post-CVC knowledge acquisition process.

Third, this study contributes to the literature on innovation strategy through the empirical analysis that takes into account both quantitative and qualitative dimensions of innovation performance. We did not only look at how many patents were created after the CVC investments, but also analyzed how many other patents cite the corporate investor's patents. The results of the analysis show that the quality of newly created innovations may differ according to the level of autonomy given to the CVC investment. This can be an important challenge for both the scholars who study CVC as a firm's innovation strategy, and the firms who actually conduct CVC investments.

Finally, this study provides managerial implications to corporate investors. Based on the results of our analysis, we can provide the following strategic suggestions for firms: First, in the target searching phase before the actual investment takes place, CVC units must ensure whether the industry in which the potential target company belongs and the knowledge they possess are an extension of the existing business model of the parent firm or not. If the potential target company is engaged in an area completely unrelated to the parent firm's existing business, providing a high level of autonomy with regards to the investment activities to the CVC unit will be a better strategy for achieving a high explorative innovation performance. On the other hand, if the potential target company's business items and technologies are more closely related to the parent company's existing business, it would be more advantageous to conduct the investment in a close relationship 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 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 responsible for exploitation should be able to form a close relationship with the experts and technical resources of the parent firm.

5.2. Limitations and future research

While providing important insights into the relationship between the CVC unit's structural autonomy and two specific kinds of innovation performance, our study has several theoretical and analytical limitations.

First, this study has the limitation of using an oversimplified measure for the independent variable. The CVC unit's structural autonomy level, the independent variable of this study, was measured as a dichotomous variable. Autonomy levels were defined according to whether each CVC deal was carried out as a corporate investor's direct investment or as a CVC dedicated subsidiary's independent investment. However, if we look more closely, even if a firm conducts CVC investments through an independent subsidiary, there may be cases of relatively high interference from the parent firm. On the other hand, there is the possibility that relatively higher autonomy is given to direct CVC investment through a department located within the organization of the corporate investor. Moreover, with this rough variable, it is difficult to analyze the various dimensions of autonomy given to the CVC unit (e.g., autonomy in decision making, financial resources, or human resources). If future research can develop finer-grained measurements that reflect these various aspects of autonomy, more a detailed analysis of the strategic roles of the CVC unit's autonomy will be possible.

Second, there is a data limitation on the measures for the firms' innovation performance used in this study. In our data-set, the creation of new technology is captured using patent application data. Since not every technological innovation might result in a patent application, the findings of this study do not account for the creation of non-codified and tacit knowledge (Wadhwa & Kotha, 2006). In addition, sometimes firms, fearing imitation by other competitors, are reluctant to disclose their technologies through patents, Therefore, the empirical results of this study might underestimate the effect of CVC investments on the firm's innovation activities. We propose future research to investigate other variables such as the development of new products or the creation of non-patented new knowledge.

Finally, this study has the limitation of not being able to directly count the flow of knowledge from the portfolio companies to the parent firm. In this study, new patents applied by the corporate investor after the CVC investment are regarded as innovation performance resulting from the CVC investment. Of course, while we controlled for some other factors such as internal R&D activities or M&A and alliance experiences that are known to affect the innovation performance of corporate investors, the limitation of not being able to confirm whether the dependent variables presently are only affected by the CVC investment remains. The patenting information of the investment target firms might allow figuring out how knowledge is acquired by the corporate investor. Unfortunately, however, most target companies (i.e., start-ups) in our sample have not applied for patents (yet). Future research could collect more detailed data including patent records of portfolio companies, which would allow examining the knowledge flow from the portfolio companies to corporate investors.

In conclusion, we hope that our study contributes to the research on the organizational operation of CVC investments, specifically the autonomy level of the CVC unit. Also, we hope that our research will help further research to explore the strategic values of CVC investments as an external learning method.

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