Governing Innovation: How Governance Factors Affect the Relationship Between CVC Investments and Firm Innovation

Niek G.A. van Weert
S1124331
Nijmegen School of Management, Radboud University
MAN-MSTTH: Master's Thesis in Strategic Management
Supervisor: Dr. Stefan Breet
Second examiner: V.H. Gonzalez Jimenez
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Abstract

This thesis assesses how governance factors influence the relationship between corporate venture capital (CVC) investments and firm innovation. With CVC being widely recognized as a strategic mechanism for firms to access external knowledge and thereby boost innovation, the conditions under which it leads to preferable innovation outcomes remain inconclusive. Building on literature from knowledge creation and the upper echelons theory, this study examines the moderating role of ownership stake and CEO characteristics, specifically CEO age, tenure and educational level. The analysis was done applying a fixed effects panel regression on an unbalanced panel dataset, consisting of 1.840 global firms across 25.368 firm-year observations between 2002-2024. The results confirm that an increase in CVC investments is positively associated with an increase in patenting output. Furthermore, younger and shorter-tenured CEOs significantly strengthen this relationship, while ownership stake and CEO educational level do not affect the relationship. This contributes to theory by not only strengthening the established relationship between CVC and innovation, but also by adding to it by explaining how CEO characteristics play an important role in shaping the success of this relationship. For practitioners, the findings suggest that innovation-seeking firms should consider the role of the CEO within CVC and focus on building high-quality interactions with firms, rather than increasing ownership. The insights of this study are therefore relevant for both scholars and practitioners.

Preface

The completion of this thesis marks the final step of earning my Master's degree in Business Administration, specializing in Strategic Management. Over the past two years, Radboud University has enabled me to peer into the world of academic research and I am happy to say I have thoroughly enjoyed my time here, both academically and socially. I would like to give my sincere thanks to those who have helped me in completing this master's thesis. First of all, I would like to thank my supervisor, Stefan Breet, for supporting and guiding me along the way. Secondly, I would like to thank my friends and family for their support, especially those who also spent the last few months working on their thesis and thus being my "partners in crime". Lastly, I would like to thank Noah Grim for helping me construct my dataset.

I hope you find this thesis insightful to read,

Niek van Weert,
June 15, 2025

Introduction

Corporate venture capital (CVC) has become an essential mechanism for firms seeking to enhance their innovation capabilities and gain competitive advantages in rapidly evolving industries (Bottazzi et al., 2004; Dushnitsky & Lenox, 2005b, 2005c; Wadhwa & Kotha, 2006). CVC is the practice of minority equity investment by established firms in entrepreneurial ventures, that is, innovative companies that seek capital to continue operations (Dushnitsky & Shapira, 2010). Unlike independent venture capital (IVC), which primarily focuses on financial returns, CVC investments are often strategically motivated, allowing firms to gain access to external knowledge and emerging technologies (Dushnitsky & Lenox, 2005b; Schildt et al., 2005). Prior research has demonstrated that CVC investments can serve as an important driver of firm-level innovation by facilitating knowledge spillovers and fostering collaboration between established corporations and entrepreneurial firms (Bottazzi et al., 2004; Dushnitsky & Lenox, 2005b, 2005c; Hill et al., 2009; Hoetker & Agarwal, 2007; Yang et al., 2013). However, the effectiveness of CVC in generating innovation outcomes remains inconsistent across firms, with varying studies showing varying results (Dushnitsky & Lenox, 2005b; Keil et al., 2008; Wadhwa & Kotha, 2006). Considering the CVC market manages more than $150 billion yearly, a lot depends on incomplete, and therefore limited, knowledge (Anokhin et al., 2024). With such extensive investment sizes, and considering that these investments can fail, this raises critical questions about the conditions under which CVC investments contribute to firm innovation, and thereby can be considered successful investments.

Existing literature has outlined both how varying governance factors influence the strategic motivations behind choosing CVC investments, as well as how they influence knowledge sharing and creation between firms (Anokhin et al., 2016; Chen & Nadkarni, 2016; Garg et al., 2025; Pahnke et al., 2015; Paik & Woo, 2017; Schückes et al., 2024). However, limited attention has been given to its role in moderating the relationship between CVC investments and innovation performance for the investing firm. Specifically, research indicates how ownership stake and CEO characteristics might play a significant role in shaping the innovation outcomes of firms. Adding to the described line of reasoning regarding gaining knowledge and thereby innovation, research suggests that having a greater stake in the entrepreneurial firm should enhance this potential of learning by the investing firm (Bottazzi et al., 2004; Dushnitsky & Lenox, 2005b, 2005c; Hill et al., 2009; Paik & Woo, 2017). Additionally, research suggests that the role of the investing firms' CEO is crucial in

determining the effect CVC investments have on innovation (Hambrick & Fukutomi, 1991; Hambrick & Mason, 1984; Henderson et al., 2006; Miller, 1991; Simsek, 2007; Wu et al., 2005). Specifically, a CEO's characteristics might determine, in part, the extent of innovation outcomes as a result of CVC investments. However, empirical evidence on the effect these governance factors have in this context is limited and the existing findings are conflicting. This lack of clarity and empirical evidence on how governance factors enable or constrain the innovative potential of CVC investments represents a significant gap in the literature. Addressing this gap is important, as without the understanding of the influence of governance factors, firms may fail to fully capitalize on their investments, resulting in missed innovation opportunities and thus failed investments. Conversely, understanding these factors enables firms to put adequate governance mechanisms in place, supporting firms in maximizing the innovation benefits of CVC and realizing successful investments.

To address this issue, this study examines how specific governance factors moderate the relationship between CVC investments and firm innovation. Specifically, it examines the role of ownership stake and CEO characteristics in shaping the effectiveness of CVC as an innovation provider. The corresponding research question is as follows: *How do ownership stake and CEO characteristics affect the relationship between CVC investments and firm innovation?* This study answers this question by analyzing firm-level data by employing a quantitative research design and applying fixed effects panel regression on an unbalanced panel dataset consisting of 1.840 global firms across 25.368 firm-year observations between 2002-2024. This approach allows for a systematic evaluation of the interaction between governance factors, CVC investments and firm innovation. The study finds that increases in CVC investments are associated with increases in patenting counts. Furthermore, the study finds that younger and shorter-tenured CEOs strengthen this relationship, while greater ownership and higher educated CEOs do not affect the relationship.

These findings contribute to the literature by strengthening the argument for corporate venturing as a cause of learning and innovation. Specifically, it shows how an increase in corporate investment activity results in additional learning. The study also shows that once learning routes are set in place, greater ownership of an entrepreneurial firm does not necessarily increase the learning potential of these routes, suggesting that the quality of interaction between firms is crucial for success. The study implies that the CEO plays a role in this interaction quality, wherein a CEOs characteristics shape not only an executive's own perception and response to strategic situations and thereby organizational outcomes, but also that of personnel with considerable distance from the CEO. Given the increasing reliance on

CVC as a corporate innovation strategy, understanding the governance conditions that facilitate successful CVC investments is essential for both academics and practitioners. This study is therefore relevant for scholars as it adds understanding to the interaction of literatures of corporate governance, strategic management, corporate entrepreneurship and knowledge creation. Enhancing understanding of this topic also leads to practical implications for firms. By understanding what governance factors enhance innovation through corporate venturing, firms can put structures in place to fully capitalize on the innovative benefits of CVC.

Theoretical background

Traditionally, corporate entrepreneurship (CE) has been described as entrepreneurial behavior inside larger organizations (Stopford & Baden-Fuller, 1994). Traditional research has also mentioned it to be important for the survival of organizations, profitability, growth and renewal (Zahra, 1996). Through the years, CE has evolved and so has its definition. More recently, CE has been described as consisting of three main domains: corporate venture capital, strategic entrepreneurship and entrepreneurial orientation (Kuratko & Covin, 2021). CVC entails established firms investing in other ventures, with the goal of learning from sources beyond the boundaries of the firm (Schildt et al., 2005). Firms often find difficulty in sustaining knowledge competitiveness solely through internal development (Christensen & Bower, 1996; Henderson & Clark, 1990). Therefore, corporations increasingly make use of CVC investments to overcome this (Dushnitsky & Lenox, 2005a; Wadhwa & Kotha, 2006).

Battistini et al. (2013) regard corporate venturing as a model for business innovation. CVC usually takes the form of established corporations acquiring minority stakes in externally founded ventures (Drover et al., 2017). However, it can also take the form of established corporations investing in internally founded ventures (Miles & Covin, 2002). More specifically, CVC is the practice of minority equity investment by established firms in entrepreneurial ventures, that is, innovative companies that seek capital to continue operations (Dushnitsky & Shapira, 2010). It therefore shares similarities to other entrepreneurial equity investments and is part of this equity funding landscape (Drover et al., 2017). The most comparable method in this landscape is venture capitalists (VC). This is the most widely recognized form of equity financing (Drover et al., 2017). In this form, venture capitalists obtain funding from limited partners with the goal of providing a return to these investors (Gompers & Lerner, 2000). This form is more focused on short-term financial returns, relative to CVC, because VCs provide returns to their limited partners within about 10 years (Drover et al., 2017). As corporate investors are looking for long-term value for their firms, this differs significantly from independent VC programs (Drover et al., 2017).

A corporate investor also essentially starts a sort of alliance with the entrepreneurial firm it invests in. Corporate investors provide specific advantages over regular VCs by leveraging unique services that capitalize on corporate resources (Dushnitsky & Shaver, 2009). Firstly, CVCs can offer entrepreneurial firms access to laboratories, customer- and supplier networks and distribution networks (Acs et al., 1997; Teece, 1986). Secondly, having backing from a corporate investor functions as an endorsement to the capital markets

(Gompers & Lerner, 1998; Stuart et al., 1999). This creates an interaction wherein entrepreneurial firms want CVC backing but do not want the CVC firm to copy ideas, while the CVC does want to learn from the firm it invests in (Dushnitsky & Shaver, 2009). This interaction shows that CVC investments differ from VC because it has financial, as well as strategic goals (Battistini et al., 2011). This knowledge sharing between both parties has implications for firm innovation (Dushnitsky & Lenox, 2005b).

CVC and firm innovation through knowledge creation

One of the first to prove a relationship between CVC investment and firm innovation were Dushnitsky and Lenox (2005b). The authors showed how an increase in CVC investments leads to an increase in firm innovation. Corporate venturing allows investing firms to access knowledge from entrepreneurial firms through their interaction (Dushnitsky & Lenox, 2005b). Additionally, Wadhwa and Kotha (2006) conceptualized CVC investments as an exploratory process through which firms attempt to access new knowledge that would otherwise not be available. This learning between firms occurs through several routes. Firstly, investing firms can gain entrepreneurial knowledge through the due diligence process that occurs before a potential investment decision is made (Yang et al., 2013). Second, investing firms often gain knowledge about key activities and technologies of the firm it invests in, through access to the board of the firm it invests in, either through a board seat or observation rights (Bottazzi et al., 2004; Dushnitsky & Lenox, 2005b, 2005c; Hill et al., 2009). Thirdly, after investing has actually happened, investing firms often visit and monitor the operations of firms they invest in (Bottazzi et al., 2004) and form close working groups between both firms (Dushnitsky & Lenox, 2005c). And lastly, investing firms can learn from failing firms it has invested in, when its technologies remain usable (Hoetker & Agarwal, 2007). This research shows how investing firms use CVC investments to gain firm innovativeness and elaborates how the main effect between the two works. However, the direction and shape of the relationship are not yet fully understood, as various factors influence an investing firm's ability to capture and create knowledge through CVC investments.

Firstly, Dushnitsky and Lenox (2005b) find that firms using CVC investments realize higher future innovation rates overall, reflected in an increased number of citation-weighted patents. However, the extent to which firms benefit from CVC investments depends on absorptive capacity and intellectual property (IP) protection (Dushnitsky & Lenox, 2005b). The effect of CVC investments on innovation is stronger in weak IP regimes, because firms gain greater access to knowledge from the entrepreneurial firm, and the effect is weaker in

strong IP regimes, because legal protections limit knowledge spillover (Dushnitsky & Lenox, 2005b). Regarding absorptive capacity, investing firms with stronger R&D capabilities benefit more from CVC investments because these can better assimilate and apply external knowledge (Cohen & Levinthal, 1990; Dushnitsky & Lenox, 2005b). Additionally, the authors found that when both firms overlap in their technological knowledge sets, the relationship between CVC investments and the innovative advantages follows an inverted U-shape, wherein moderate overlap maximizes learning benefits (Ahuja & Katila, 2001; Dushnitsky & Lenox, 2005b).

Secondly, Keil et al. (2008) show that relatedness between the investing firm and the entrepreneurial firm influences the relationship between CVC investment and innovative performance, again following an inverted U-shape. This means that investing in moderately related firms leads to the best innovative performance, wherein too much similarity leads to redundant knowledge, while too much distance hinders knowledge absorption and integration (Keil et al., 2008).

Thirdly, Wadhwa and Kotha (2006) show that the influence of CVC investments is limited, wherein an inverted U-shape was revealed, meaning that moderate CVC investment levels maximize knowledge creation. However, high involvement from investors in the entrepreneurial firms can reverse the decline of high levels of CVC investment, showing the importance of active involvement (Wadhwa & Kotha, 2006). The authors show how high investor involvement leads to a U-shaped relationship between CVC investments and knowledge creation.

Therefore, further understanding this relationship adequately is important for both theoretical and practical implications. Indeed, different studies and contexts show varying results. Scholars of strategic management and entrepreneurship are therefore interested in the question of how. What is missing in this relationship for us to fully understand it? Furthermore, managers of corporate investing firms will want to know under what conditions they can collaborate with entrepreneurial firms to gain firm innovation. Similarly, the results will have implications for managers of entrepreneurial firms. Following previous research, the first hypothesis is:

Hypothesis 1 (H1): An increase in CVC investments leads to an increase in firm innovation.

Moderating effects of governance factors

Pahnke et al. (2015) examine how institutional logics, which are the underlying norms, structures and practices of different funding partners, affect the innovation outcomes of entrepreneurial firms. The study shows how different investment partners vary significantly in their effectiveness in fostering innovation, wherein CVCs contribute less effectively to innovation compared to VCs, despite their access to significant corporate resources (Pahnke et al., 2015). The authors explain how governance factors like decision-making structures, internal bureaucracy and conflicts and structural complexity determine the effectiveness of CVC investments. Although this research is focused on the innovativeness of entrepreneurial firms rather than the investing firms, it does show that governance is related to the subject of innovation in the context of CVC investments and might be translated into other governance mechanisms. Additionally, Schückes et al. (2024) explore how CVC units structure themselves to drive innovation while managing tensions between the investing firm and the entrepreneurial firm. The findings highlight how highly autonomous CVC units are more effective at exploring disruptive innovations, however strong integration with the investing firm allows CVC units to better leverage internal resources and facilitate knowledge transfer, enhancing exploitation of external innovations (Schückes et al., 2024). This also highlights how governance factors play a significant role in achieving innovation output. Previous research has considered governance factors as antecedents to CVC activity, however research is limited as to what the eventual effect of these governance factors is on the success of CVC investments on firm innovation.

Firstly, Anokhin et al. (2016) examine how ownership structure influences CVC activity, highlighting the role of institutional ownership and concentrated ownership in shaping investment decisions of firms. The authors found that institutional ownership is positively associated with CVC activity, as institutional investors tend to prioritize long-term innovation strategies. Conversely, concentrated ownership negatively influences CVC activity, as these investors tend to prioritize financial stability over riskier, exploratory investments (Anokhin et al., 2016). Additionally, Paik and Woo (2017) found that ownership plays a significant role in shaping an entrepreneurial firm's R&D investment strategy. The results show that greater investing firms' ownership of an entrepreneurial firm leads to greater R&D intensity of the entrepreneurial firm. This is because investing firms with greater equity stakes have more influence over strategic decision-making (Paik & Woo, 2017). This shares reasoning with the earlier described potential for learning through access to the board of the entrepreneurial firm (Bottazzi et al., 2004; Dushnitsky & Lenox, 2005b, 2005c; Hill et al.,

2009). Paik and Woo (2017) also found that the interaction between investing firms' ownership and founder incumbency amplifies this effect. Building on these insights, it seems reasonable to expect that greater ownership of the entrepreneurial firm leads to more innovation in this firm, meaning that there is more knowledge for the investing firm to learn from. Conversely, having a small stake in the entrepreneurial firm might lead to lower knowledge absorption and thus lower innovation outcomes. It therefore becomes relevant to examine whether a greater ownership stake by the investing firm further enhances the innovative performance of this firm. However, research has not yet shed light on the effects of this on investing firms' innovation performance. Considering this, the following hypothesis is proposed:

Hypothesis 2 (H2): Ownership stake moderates the relationship between CVC investments and firm innovation, such that higher investing firms' ownership of an entrepreneurial firm strengthens this relationship.

Secondly, Chen and Nadkarni (2016) shed light on how CEO temporal dispositions, specifically time urgency and pacing style, shape entrepreneurial outcomes, including innovation, corporate venturing and strategic renewal. The study shows how CEO's time urgency positively influences corporate entrepreneurship, while different CEO pacing styles yield different effects on corporate entrepreneurship. Therefore, Chen and Nadkarni (2016) highlight the relationship between CEO characteristics and corporate venturing. This begs the question of how CEO characteristics influence the relationship between CVC investments and firm innovation. In a similar vein, Wiersema and Bantel (1992) provided foundational evidence that top management characteristics, like age, education and tenure, influence corporate change. Specifically, the authors found that lower age, shorter organizational tenure and higher educational level are more likely to undergo changes in corporate strategy, under which corporate entrepreneurship. Similarly, Garg et al. (2025) found that characteristics like diversity in experience, tenure and functional backgrounds of top management teams positively influence the likelihood of engaging in CVC investments. Building on this prior knowledge, a key question is whether these CEO characteristics also shape the relationship between CVC investments and firm innovation. This is consistent with the upper echelons theory perspective, as first proposed by Hambrick and Mason (1984). The fundamental premise of this theory is that executives' characteristics shape how they perceive and respond to strategic situations, and thus shape organizational outcomes (Hambrick & Mason, 1984).

Specifically, the authors state that these outcomes, defined as strategic choices and performance levels, are partially predicted by the background characteristics of top executives. Importantly, Hambrick (2007) stated that demographic characteristics of executives (including CEOs) can serve as valid indicators of their cognitive frames, even though they are incomplete and imprecise. Therefore, these characteristics can be used to develop predictions of strategic actions (Hambrick, 2007). The authors outline several observable upper management characteristics (Hambrick & Mason, 1984). Considering this is one of the first studies to essentially test whether or not the upper echelons theory holds up in the context of CVC investments and its effect on firm innovation, this study is limited to testing the most promising characteristics. Following the findings of Wiersema and Bantel (1992), this study therefore focuses on the following three most promising CEO characteristics.

The first characteristic considered to be relevant is age, wherein youth appears to be related to corporate growth (Child, 1974; Hart & Mellors, 1970). Older executives seem to have a more conservative stance for three reasons (Hambrick & Mason, 1984). Firstly, older age may experience a decline in physical and mental stamina, making it more difficult to absorb new ideas and adapt to unfamiliar behaviours (Child, 1974; Chown, 1960; Taylor, 1975). Secondly, older age often shows a stronger psychological attachment to the organizational status quo, making the initiative of transformative or innovative actions less likely (Stevens et al., 1978). Thirdly, concerns regarding financial and career security may make older managers more risk-averse, wherein they are more likely to avoid decisions that could disrupt their established stability (Carlsson & Karlsson, 1970). Therefore, lower age seems to improve innovation outcomes.

Hypothesis 3a (H3a): CEO age moderates the relationship between CVC investments and firm innovation, such that lower CEO age strengthens this relationship.

The second characteristic considered is tenure. In addition to the earlier described implications of both Wiersema and Bantel (1992) and Garg et al. (2025), research shows that CEOs with longer tenure cease to make adaptive changes and essentially grow “stale in the saddle” (Hambrick & Fukutomi, 1991; Henderson et al., 2006; Miller, 1991; Wu et al., 2005). Regrettably however, research has not provided adequate insights as to the why, because few researchers possess the required skill set for this type of research, and because research into psychological and social processes is exceedingly difficult (Hambrick, 2007). Contrary to

earlier findings, Simsek (2007) found that longer tenured CEOs encourage more top management team risk-taking, which in turn boosts entrepreneurial initiatives and enhances firm performance. As a sort of compromising addition to research, Ng and Feldman (2010) show how tenure has a positive relationship with job performance, but a negative relationship with adaptability and innovation. These conflicting findings raise significant questions about how a CEO's tenure influences the relationship between CVC investments and firm innovation. Because the majority of research supports the benefits of shorter tenure, I propose the following hypothesis:

Hypothesis 3b (H3b): CEO tenure moderates the relationship between CVC investments and firm innovation, such that shorter CEO tenure strengthens this relationship.

The third and last considered characteristic is education. Adding to the earlier mentioned insights from Wiersema & Bantel (1992), earlier research has consistently shown that higher educational level is positively related to receptivity to innovation (Becker, 1970; Kimberly & Evanisko, 1981). This is because education gives insight into a person's knowledge and skill base (Hambrick & Mason, 1984). Specifically, Hamrick and Mason (1984) address how the amount, not the type of formal education, is positively associated with innovation. The authors also argue that education, to some extent, reflects a person's underlying values and cognitive preferences. Hence,

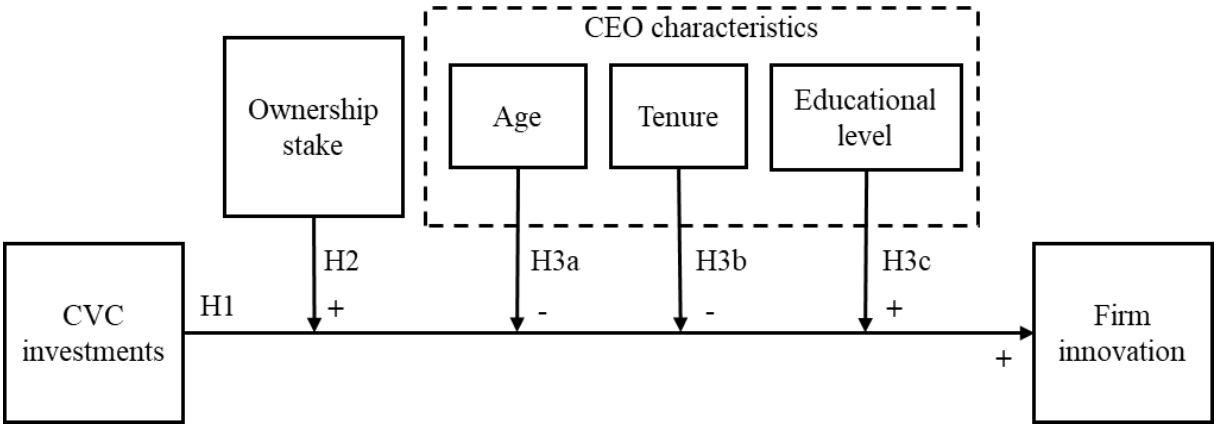
Hypothesis 3c (H3c): CEO educational level moderates the relationship between CVC investments and firm innovation, such that higher CEO educational level strengthens this relationship.

Conceptual model

Previous sections highlighted both the need for better understanding of the relationship between CVC investments and firm innovation, as well as the role governance factors have in CVC activity. The combination of this results in the conceptual model presented in figure 1. The corresponding research question is: How do ownership stake and CEO characteristics affect the relationship between CVC investments and firm innovation?

Figure 1

Conceptual model



Methodology

Empirical setting and data sources

To test the hypotheses, an unbalanced panel dataset was constructed of global listed and delisted firms during the time period 2002-2024, ensuring a broad research scope. The Orbis M&A database was used to build a sample of global listed and delisted firms that have conducted CVC deals. Additionally, the Orbis M&A database was used for retrieving SIC-codes and final stake percentages of the acquirer in the target. The LSEG Workspace database was used to provide additional financial and firm-specific data. Additionally, the BoardEx dataset was used to retrieve information regarding CEO characteristics. Lastly, the Orbis Intellectual Property database was used to provide patent information. Using ISIN codes as a common identifier, all these datasets were merged. The resulting dataset consists of 1.840 firms and 25.368 firm-year observations. It is important to note that, due to CVC investments occurring irregularly and existing data limitations, this research uses an unbalanced panel dataset, with 1.964 CVC investments made.

Measures

Firm innovation. The dependent variable, firm innovation, is measured using the three-year average of the yearly number of patent applications made by the investing firm. Patenting applications are chosen instead of patents granted because applications can take years before being granted (McCarthy & Aalbers, 2022). Related research makes use of similar innovation measures, including citation-weighted patent counts (Dushnitsky & Lenox, 2005b), annual counts of patents granted (Wadhwa & Kotha, 2006), and successful patent applications (Keil et al., 2008).

CVC investments. The independent variable, CVC investments, are specified as deal types of minority equity stakes and deal equity values of < 50%, in line with prior research (Dushnitsky & Shapira, 2010). This means that the research will only look at firms that conduct CVC activity. This is measured using CVC investment intensity, allowing more accurate comparisons across firms, consistent with approaches used in prior research (Dushnitsky & Lenox, 2005c). CVC investment intensity is calculated using revenue as follows:

$$CVC\ investment\ intensity = \frac{Total\ annual\ CVC\ investments\ deal\ value}{Net\ Revenue}$$

Table 1

Variable summary

Type variable	Variable	Label	Operationalization	Transformations
Dependent	Firm innovation	filedavg1_3	Average number of filed patents in the three years following the observation year (t + 1 to t + 3).	Natural logarithm
Independent	CVC investments	CVC_INT	$\frac{Total\ annual\ CVC\ investments\ deal\ value}{Net\ Revenue}$	Winsorization, Centered
Moderators	Ownership stake	finalstake_avg	Final average equity stake the investing firm has in the entrepreneurial firm	Centered
	CEO age	ceo_age	Age in years of the CEO of the investing firm at the moment of investment	Centered
	CEO tenure	ceotenurefocal	Duration of a CEO's time in office in years	Natural logarithm, Centered
	CEO educational level	ceo_amount_education	Highest obtained degree, measured through years	Centered
Controls	Firm size	EMP	Total number of employees	Natural logarithm
	R&D expenditure	RD_INT	Research and Development/ Sales	Winsorization
	Industry relatedness	industryrelatedness_ratio	Ratio of relatedness, wherein related means the 1st digit of SIC-codes are equal	

Moderators. The moderator variables of this research are ownership stake and the CEO's characteristics. Ownership stake is operationalized as the final average equity stake the investing firm has in the entrepreneurial firm, again excluding majority stakes. Regarding CEO characteristics, CEO age is measured by age in years of the CEO of the investing firm, in the year of CVC investment. Tenure is operationalized as the duration of a CEO's time in office, measured in years. Lastly, CEO educational level is measured by the highest obtained degree, in line with established prior research (Hambrick & Mason, 1984; Kimberly & Evanisko, 1981). The highest obtained degree in the BoardEx dataset is operationalized through the number of years the CEO followed education.

Controls. This research controls for investing firm size, industry relatedness and R&D expenditure, in line with previous research (Dushnitsky & Lenox, 2005b; Keil et al., 2008; Wadhwa & Kotha, 2006). Operationalization of these variables is done through, firstly using the total number of employees of the investing firm to measure firm size. Secondly, industry relatedness will be measured through SIC-codes of the acquirer and target companies. Specifically, if the first digit of the SIC-codes are equal, the firms are considered related (Keil et al., 2008). Because an investing firm can conduct multiple CVC investments in the same year, a percentage of the amount of related deals is given. Lastly, R&D expenditure will be measured using R&D intensity to separate R&D effects from size effects (Hall & Ziedonis, 2001). R&D intensity is retrieved from LSEG using the "Research and Development/ Sales" variable. Table 1 shows a variable summary of all measures included in this research.

Method of analysis

The hypotheses were tested by applying a fixed effects panel regression model, comparable to earlier research (Dushnitsky & Lenox, 2005b). Given that the hypotheses focus on within-firm changes of CVC investments on firm innovation, a fixed effect model is appropriate. Additionally, to assess what approach is best suited for the data, a Hausman test was conducted (Wooldridge, 2001). The results show that a fixed effects approach is appropriate (Appendix H). This panel regression with firm and year fixed effects approach controls for both unobserved, time-invariant firm characteristics as well as year effects that affect all firms equally in each time period (Wooldridge, 2001). Despite this method reducing the sample size, this remains the preferred method due to it reducing omitted variable bias and improving internal validity (Wooldridge, 2001). The analysis was done using STATA, using a significance level (α) of 0,05 to determine statistical significance. Comparable research makes use of lagged independent variables due to innovation effects coming into effect over time

(Dushnitky & Lenox, 2005b; Wadhwa & Kotha, 2006). Therefore, this research assessed several combinations of lagged CVC intensity variables, lead and averaged firm innovation variables. After the most suitable combination was decided, the additional models were tested. Overall, this research adopts a hierarchical approach, wherein control variables were added first, followed by the independent variable and lastly the moderators. To assess the effect of individual moderators, these were tested separately. Therefore, the different models were tested on partially overlapping, but varying samples. For each sample, only firms with complete data for all included variables were used. While the full dataset includes 1.964 observations for the independent variable, the number of observations per model varies from 69 to 541 (Table 3).

Research ethics

This research follows the ethical principles outlined in the APA Ethics Code, ensuring transparency, integrity and academic rigor throughout the research process. As the data used in this research is taken from databases available to the university, there is no violation of corporate privacy or confidentiality concerns. Furthermore, all data transformations, coding procedures and analytical methods will be documented to ensure replicability and prevent data misrepresentation. Similarly, all research data will be archived in line with Radboud University's data management policy (*Guidelines For Research Data Management | Radboud University*, 2023). Ethical considerations also include making explicit any assumptions based on existing literature and ensuring findings are reported objectively. Additionally, a research integrity form was signed, reinforcing the commitment to ethical research practices.

Results

Data examination and preparation

First of all, the lagged, lead and averaged variables for CVC investments and firm innovation were constructed. The decision-making process for determining the final combination of variables is discussed later in this chapter. The chosen variables are CVC investments at time *t* and the average number of filed patents in the three years following the observation year (*t* + 1 to *t* + 3). After this, the descriptive statistics of all variables before any transformations were assessed (Appendix A). Upon inspection of the shape of the variables, several variables did not lie within the recommended range for skewness (-3 and +3) and kurtosis (-7 and +7). This should be addressed due to issues regarding normality and homoscedasticity (Hair et al., 2019). All variables outside the recommended range were transformed using the natural logarithm, wherein constants of 1 were added to variables with minimum values of 0. Additionally, both intensity variables remained outside the acceptable ranges due to outliers. Because of this, the log-transformed variables of CVC investments and R&D expenditure were transformed again using winsorization at the 1st and 99th percentiles and 5th and 95th percentiles, respectively. Before creating interaction terms, CVC investments and all moderator variables were mean-centered to correct for possible multicollinearity (Hair et al., 2019). Lastly, the independent variable CVC investments was squared to assess a potential curvilinear relationship with firm innovation (Hair et al., 2019). Table 2 shows the resulting descriptive statistics. This shows how all mean-centered values have a mean of 0. Noteworthy as well is how the CVC investments variable still has a kurtosis value outside the recommended range. However, considering the values have been improved drastically compared to before transformations, this is accepted.

Table 2

Descriptive statistics after transformations

Variable	N	Mean	SD	Min	Median	Max	Skewness	Kurtosis
Firm innovation	8420	4.151	2.543	0	4.007	10.922	.195	2.109
CVC investments	1964	0	0.319	-.125	-.112	1.244	3.286	12.645

Ownership stake	2859	0	13.592	-25.203	-.575	24.787	.219	2.002
CEO age	7394	0	7.318	-25.426	.574	39.574	.156	4.022
CEO tenure	17878	0	0.780	-1.485	.007	2.629	.154	2.399
CEO educational level	15862	0	2.262	-5.288	.712	3.712	-.286	3.423
Firm size	21937	8.615	2.313	0	8.931	14.648	-.739	3.533
R&D expenditure	11762	4.857	6.735	0	2.05	24.78	1.812	5.348
Industry relatedness	3052	.608	0.480	0	1	1	-.44	1.23

Appendix B depicts the correlation matrix and provides insight into the relationship between the variables. Following Hair et al. (2019), values of 0.3 are considered medium correlations, with values exceeding 0.9 indicating possible multicollinearity. None of the values exceed the 0.9 threshold. The control variable firm size has a medium to strong correlation with firm innovation ($r = 0.461$) and CVC investments ($r = -0.412$). Control variable R&D expenditure also has a medium correlation with CVC investments ($r = 0.348$). Given the importance of both variables as controls, the decision was made not to exclude either.

Testing assumptions

The assumption of normally distributed error terms was examined using a P-Plot (Appendix C). Visual inspection of this plot shows a slight S-shaped pattern, though not substantial enough to violate the assumption of normality. In order to test the assumption of homoscedasticity, the scatterplot was examined (Appendix D). This scatterplot shows an irregular dispersion across values of the independent variable firm innovation, indicating a potential heteroscedastic relationship (Hair et al., 2019). Therefore, a modified Wald test for groupwise heteroscedasticity was conducted (Baum, 2001). The result was significant ($\chi^2(383) = 81{,}575.24$, $p < 0.001$), indicating heteroscedasticity across firms. Therefore, robust standard errors were used in all regressions to correct for this violation (Hair et al., 2019). The scatterplot was also used to examine linearity. Again, due to the plot showing irregular dispersion, a polynomial term of the independent variable was included in the model to test

for a potential curvilinear relationship (Hair et al., 2019). Due to this study applying a panel regression analysis with both firm- and year fixed effects and robust standard errors, it accommodates for the potential violation of independence of error terms (Hair et al., 2019). Lastly, multicollinearity between variables was assessed using the variance inflation factor (VIF). Appendix E shows the VIF scores for the models with controls and the independent variable, as well as each moderator variable. All VIF values should be below 10 and the tolerance values above 0.10 (Hair et al., 2019). As all VIF values do not violate these thresholds, the extent to which any of the variables can be explained by another is not problematic (Hair et al., 2019).

Results regression analysis

Before estimating the main models, the several combinations of lagged, lead and averaged CVC investments and firm innovation variables were assessed. To do this, mainly models with control variables and the independent variable were assessed to determine the strongest fit for the main effect. Important factors for determining the best fit are sample size, significance of main effect, significance of controls, R-squared and theoretical considerations. The models using lagged variables of CVC investments were discarded due to low sample sizes, especially when adding moderators to the analysis. Appendix F shows the remaining models after taking significance into consideration. The model using the average patent applications 1-3 years after investment was chosen as the base model. This is due to the earlier outlined factors and the relevant consideration of innovation returns being most noticeable 2-3 years after investment (Dushnitsky & Lenox, 2005b). After this, the base model was extended with all relevant variables. Table 3 depicts the results of the panel regression analysis.

Model 1 serves as the base model and includes control variables. Both firm size ($\beta = 0.249$, $p < 0.05$) and R&D expenditure ($\beta = 0.195$, $p < 0.05$) are positively significant, while industry relatedness is not ($\beta = -0.015$, $p > 0.05$). The within R-squared is 0.523, indicating a good model fit based on within-firm variation. With this model having 541 observations across 362 firms, it has the strongest sample size of all models, with the most robust findings compared to the other models with smaller sample sizes.

Model 2 includes the control variables as well as the independent variables and therefore tests Hypothesis 1, suggesting a positive linear relationship between CVC investments and firm innovation. The linear term for CVC investments is positively significant ($\beta = 1.427$, $p < 0.05$), while the squared term is negative and non-significant ($\beta =$

3.070, $p > 0.05$). Both firm size ($\beta = 0.155$, $p < 0.05$) and R&D expenditure ($\beta = 0.197$, $p < 0.05$) remain positive and significant, while industry relatedness again is not ($\beta = 0.093$, $p > 0.05$). The within R-squared increases to 0.632, showing an improved model fit. Due to the model assessing a limited number of 356 observations across 252 firms, the within- and between-firm variation was analyzed (Appendix G). This analysis shows a limited variation within firms over time for CVC investments (SD = 0.12), while the average number of observations per firm is also limited (T-bar = 1.5). Considering the analysis method of this research assesses within-firm variation over time, this raises some concerns regarding the interpretation of this and future models. Despite these concerns, Model 2 indicates a linear relationship between CVC investments and firm innovation and therefore supports Hypothesis 1.

Model 3 and onwards includes the control variables, independent variable and tests the moderators individually. Model 3 tests Hypothesis 2, proposing that higher ownership stake strengthens the positive effect of CVC investments on firm innovation. The interaction term of ownership stake is negative and non-significant ($\beta = -0.065$, $p > 0.05$), while the main effect of ownership stake is negative and also non-significant ($\beta = -0.00789$, $p > 0.05$). This shows no support for Hypothesis 2. The linear term for CVC investments remains positive but non-significant ($\beta = 0.955$, $p > 0.05$), while the squared term is negative but also non-significant ($\beta = -4.419$, $p > 0.05$). R&D expenditure remains positively significant ($\beta = 0.193$, $p < 0.05$), while firm size ($\beta = 0.118$, $p > 0.05$) and industry relatedness ($\beta = 0.0955$, $p > 0.05$) are positively non-significant. The within R-squared increases to 0.659, reflecting a strong model fit. Due to the limited number of observations (349) compared to firms (247), the within- and between-firm variations were assessed again (Appendix G). While ownership stake shows adequate within-firm variation (SD = 7.48), the interaction term shows limited within-firm variation (SD = 1.53). Considering this, combined with low T-bar scores (1.6 and 1.5, respectively), this model also raises concerns regarding interpretation. Overall, Hypothesis 2 is not supported.

Model 4 tests the first CEO characteristic, age. The interaction term is negative and significant ($\beta = -33.25$, $p < 0.05$), showing support for the hypothesis that the impact of CVC investments on innovation decreases as CEO age increases. The main effect of CEO age is also negatively significant ($\beta = -4.288$, $p < 0.05$), indicating that older CEOs are associated with lower firm innovation. Both the linear ($\beta = 142.1$, $p < 0.05$) and the squared ($\beta = -856.0$, $p < 0.05$) terms for CVC investments are significant. All three control variables are negatively significant ($\beta = -2.728$, $p < 0.05$) ($\beta = -0.318$, $p < 0.05$) ($\beta = -0.594$, $p < 0.05$). The large

coefficients of all variables should be noted. Considering this, the suggested perfect model fit (R-squared = 1) and the small sample size of 69 observations across 58 firms, this model raises concerns and within-firm variation was also analyzed. While CEO age shows adequate within-firm variation (SD = 4.75) and panel size (T-bar = 11.57), the interaction term again shows limited within-firm variation (SD = 0.32) based on a relatively short panel (T-bar = 1.3). Despite this, considering the direction and significance of the hypothesized direction, Hypothesis 3a is supported.

Model 5 tests the CEO characteristic tenure. The interaction term is negatively significant ($\beta = -5.413$, $p < 0.05$), showing support for the hypothesis. The main effect of CEO tenure is also negatively significant ($\beta = -0.664$, $p < 0.05$), indicating that longer-serving CEOs are associated with lower firm innovation. The linear term for CVC investments is positive and non-significant ($\beta = 0.922$, $p > 0.05$), while the squared term is positively significant ($\beta = 11.66$, $p < 0.05$). Regarding the control variables, both firm size ($\beta = 0.831$, $p < 0.05$) and industry relatedness ($\beta = 0.224$, $p < 0.05$) are positively significant, while R&D expenditure is positive and non-significant ($\beta = 0.132$, $p > 0.05$). The within R-squared is 0.781, indicating a very strong model fit, with 223 observations across 167 firms. Despite the limited within-firm variation for both CEO tenure (SD = 0.61) and the interaction term (SD = 0.09), this model shows support for Hypothesis 3b.

Model 6 tests the third and final CEO characteristic, educational level. The interaction term is positive but non-significant ($\beta = 3.268$, $p > 0.05$), and the main effect is also positive and non-significant ($\beta = 0.264$, $p > 0.05$). These findings show no support for Hypothesis 3c. The linear term for CVC investments is positive but non-significant ($\beta = 0.261$, $p > 0.05$), while the squared term is negative and also non-significant ($\beta = -7.998$, $p > 0.05$). Regarding the control variables, firm size is negative and non-significant ($\beta = -0.00364$, $p > 0.05$), R&D expenditure is positively significant ($\beta = 0.170$, $p < 0.05$) and industry relatedness is also positive but non-significant ($\beta = 0.0766$, $p > 0.05$). The within R-squared drops to 0.520, with this model considering 179 observations across 137 firms. Considering within-firm variations of CEO educational level (SD = 1.27) and the interaction term (SD = 0.26), combined with a short panel for the interaction term (T-bar = 1.5), this model should also be interpreted with caution. Hypothesis 3c is not supported.

Table 3

Results fixed effects panel regression analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)
CVC investments		1.427**	0.955	142.1***	0.922	0.261
		(0.670)	(0.646)	(0.000933)	(1.683)	(1.731)
CVC investments^2		-3.070	-4.419*	-856.0***	11.66***	-7.998
		(2.369)	(2.349)	(0.00648)	(3.280)	(9.976)
Ownership stake			-0.00789			
			(0.00514)			
CVC*Ownership stake			-0.0648			
			(0.0496)			
Firm size	0.249***	0.155***	0.118	-2.728***	0.831***	-0.00364
	(0.0845)	(0.0548)	(0.0730)	(3.77e-05)	(0.247)	(0.459)
R&D expenditure	0.195***	0.197***	0.193***	-0.318***	0.132*	0.170***
	(0.0623)	(0.0626)	(0.0623)	(5.21e-06)	(0.0796)	(0.0627)
Industry relatedness	-0.0150	0.0932	0.0955	-0.594***	0.224**	0.0766
	(0.0903)	(0.0830)	(0.0860)	(6.29e-06)	(0.0890)	(0.102)
CEO tenure					-0.664***	
					(0.241)	
CVC*CEO tenure					-5.413***	
					(2.003)	
CEO educational level						0.264
						(0.232)
CVC*CEO educational level						3.268
						(2.059)
CEO age				-4.288***		
				(3.46e-05)		
CVC*CEO age				-33.25***		

				(0.000277)		
Constant	2.365***	3.362***	3.741***	74.01***	-3.392	4.583
	(0.824)	(0.640)	(0.749)	(0.000698)	(2.707)	(4.690)
Observations	541	356	349	69	223	179
R-squared	0.523	0.632	0.659	1.000	0.781	0.520
Number of isin	362	252	247	58	167	137
Year fe	yes	yes	yes	yes	yes	yes
firm fe	yes	yes	yes	yes	yes	yes

Reported R^2 is the within R^2, reflecting variation explained within firms over time

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4

Summary of hypotheses and empirical conclusions

Hypotheses	Expected	Empirical conclusions
Hypothesis 1 (H1): An increase in CVC investments leads to an increase in firm innovation.	+	Supported
Hypothesis 2 (H2): Ownership stake moderates the relationship between CVC investments and firm innovation, such that higher investing firms' ownership of an entrepreneurial firm strengthens this relationship.	+	Not supported
Hypothesis 3a (H3a): CEO age moderates the relationship between CVC investments and firm innovation, such that lower CEO age strengthens this relationship.	-	Supported
Hypothesis 3b (H3b): CEO tenure moderates the relationship between CVC investments and firm innovation, such that shorter CEO tenure strengthens this relationship.	-	Supported
Hypothesis 3c (H3c): CEO educational level moderates the relationship between CVC investments and firm innovation, such that higher CEO educational level strengthens this relationship.	+	Not supported

Checking robustness

To validate the robustness of the findings, the measure of the dependent variable was altered from filed patents to granted patents. Despite filed patents being a potentially more accurate measurement for firm innovation (McCarthy & Aalbers, 2022), this approach was chosen due to patents in itself being a suitable measure for innovation (Dushnitsky & Lenox, 2005b). Table 5 depicts the results of this analysis, with some models not generating an R-squared, while no model could be generated for CEO age, both due to limited observations. When comparing the results, the models with the main effect (2), ownership stake (3) and CEO educational level (5) remain relatively consistent. However, using granted patents results in no significant effect for CEO tenure, indicating the robustness of those results is low.

Table 5

Robustness check

Variables	(1)	(2)	(3)	(4)	(5)
CVC investments		2.980***	1.616	0.492	2.262
		(0.940)	(1.039)	(1.415)	(1.679)
CVC investments^2		-3.389	-2.422**	-1.204	-3.282*
		(3.493)	(1.030)	(1.441)	(1.959)
Ownership stake			-0.00183		
			(0.00476)		
CVC*Ownership stake			-0.00457		
			(0.0302)		
Firm size	0.258*	0.246**	0.921***	1.038***	1.050***
	(0.140)	(0.103)	(0.0753)	(0.0857)	(0.0893)
R&D expenditure	0.291***	0.296***	0.0998***	0.102***	0.0946***
	(0.0972)	(0.0864)	(0.0145)	(0.0179)	(0.0185)
Industry relatedness	-0.0232	0.0516	0.0951	0.0283	0.00851
	(0.107)	(0.144)	(0.122)	(0.139)	(0.151)
CEO tenure				0.270	
				(0.220)	
CVC*CEO tenure				2.895*	
				(1.605)	
CEO educational level					0.0627
					(0.0865)
CVC*CEO educational level					0.0851
					(0.662)
Constant	1.234	1.653	-4.060***	-5.295***	-5.409***
	(1.427)	(1.072)	(0.795)	(0.850)	(0.964)
Observations	518	338	331	211	168
R-squared	0.649	0.632			

Number of isin	343	238	233	157	126
Year fe	yes	yes	yes	yes	yes
firm fe	yes	yes			

Reported R^2 is the within R^2, reflecting variation explained within firms over time

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Discussion

The objective of this study is to further understand the governance conditions under which CVC investments contribute to firm innovation. The study specifically asks: *How do ownership stake and CEO characteristics affect the relationship between CVC investments and firm innovation?*. This study finds strengthening evidence of the fundamental, positive relationship between CVC investments and firm innovation. Adding to this, the findings show how a younger and shorter-tenured CEO strengthens this relationship, while greater ownership and a higher educated CEO do not affect this relationship.

Theoretical contributions

The findings of this study are consistent with prior research and add to the notion that investing in innovative, entrepreneurial firms leads to additional knowledge creation and thereby firm innovation (Dushnitsky & Lenox, 2005b; Schildt et al., 2005). This research, therefore, also strengthens the argument for CVC investments as a cause of learning and innovation. This research, which utilizes the intensity of CVC investments as a measure, also reinforces the notion that the magnitude of CVC investment a firm conducts enhances innovation. For scholars, this means that a further increase of CVC investment activity results in additional learning, strengthening existing strategic management, corporate entrepreneurship and knowledge creation literature. However, the study also shows how a higher stake in an entrepreneurial firm does not strengthen the relationship, contradicting the suggestions derived from Paik and Woo (2017). This study, therefore, suggests that a minimal amount of investment in a firm is necessary for the various learning routes to be established, but that once these are in place, additional ownership does not increase the potential of these routes. Indicating that within the boundaries of a specific entrepreneurial firm, more is not necessarily better, and that additional factors might be more critical for an effective learning relationship, such as the nature and quality of the interaction between the investing- and entrepreneurial firm. Interestingly, these findings share reasoning with earlier research, wherein the relationship between CVC investments and its outcomes follows an inverted-U shape, also indicating more is not always better (Dushnitsky & Lenox, 2005b; Keil et al., 2008; Wadhwa & Kotha, 2006). This study therefore not only strengthens this notion, but also the notion that the nature and quality of the interaction between firms is crucial.

A potentially important aspect in determining the nature and quality of the interaction between firms is the CEO's role. This study’s findings support, in part, the implications of the

upper echelons theory in the context of CVC investments, strengthening this theory (Hambrick & Mason, 1987). Specifically, the findings support the notion that youth is related to better physical and mental stamina, less psychological attachment to the status quo and less risk-averse behavior (Carlsson & Karlsson, 1970; Child, 1974; Chown, 1960; Stevens et al., 1978; Taylor, 1975). Also, the study reinforces the notion that CEOs with longer tenure tend to become "stale in the saddle," while shorter-tenured CEOs enhance innovation outcomes by making more adaptive changes (Hambrick & Fukutomi, 1991; Henderson et al., 2006; Miller, 1991; Wu et al., 2005). Investing firms' CEOs logically seem more involved in the learning routes that originate through the due diligence process, access to board seats and the potential learning when entrepreneurial firms fail (Bottazzi et al., 2004; Dushnitsky & Lenox, 2005b, 2005c; Hill et al., 2009; Hoetker & Agarwal, 2007; Yang et al., 2013). It is likely however, that the CEO's direct involvement is less apparent for the learning through monitoring operations and forming close working groups (Bottazzi et al., 2004; Dushnitsky & Lenox, 2005c). Considering the findings of this study, it implies that the underlying effect of CEOs' characteristics on shaping strategic outcomes extends beyond the direct influence of the individual executive or top management team to a more indirect, broader effect within the entire company. Considering CVC units often operate more autonomously to their parent firm compared to other divisions of the firm (Schückes et al., 2024), this study implies that this indirect effect of a CEO's characteristics reaches distant divisions nonetheless. This adds to existing literature stating characteristics shape not only an executive's own perception and response (Hambrick & Mason, 1987), but also the perception and response of personnel and divisions with considerable distance from the CEO, thus having much broader implications in the context of CVC investments.

Practical contributions

For managers, this study firstly implies that further increasing the firms' CVC activity also further increases its innovation, suggesting corporate venturing should be an ever-active process. However, firms should focus investments on seeking high-quality interactions with entrepreneurial firms, rather than acquiring a high ownership stake. When investing in entrepreneurial firms, investors should critically consider what learning routes should be established, and how to ensure high quality of these routes. This study also implies that the characteristics of a CEO are relevant for realizing this high quality. For management boards, this means it is relevant to consider that younger, shorter-tenured CEOs are beneficial for innovation outcomes in the context of CVC, and contribute to acquiring high-quality learning

routes. For boards, it is also important to consider that the characteristics of a CEO influence companywide firm performance, at least within the context of CVC and innovation.

Limitations and further research

The biggest limiting factor in this research is the limited within-firm variation due to the relatively small sample size. The current unbalanced panel regression approach with fixed effects restricts the analysis to examining changes within firms over time, which is challenging given the low number of observations per firm. Although this approach would adequately test the hypotheses when there are significant changes in the variables within firms over time, it yields uncertain results for this particular research. Considering that three moderators of this research are CEO characteristics, this approach would work best if firms included in the dataset have a change in CEO, preferably one that has significantly varying characteristics from their predecessor, as this way the effects of the different characteristics can be analyzed most effectively. Similarly, regarding ownership stake, this approach would work best if it includes firms that conduct several CVC investments with significantly different final ownership stakes. An essential suggestion for further research is therefore to utilize larger and more balanced panel datasets to enhance within-firm variations and derive more conclusive results. Additionally, this approach allows research to focus on the specific amount of ownership or investment required for the learning routes to be established. Additionally, if results regarding CEO characteristics stay consistent, research could add on this by studying other attributes of the upper echelon theory, and within a broader context of top management teams, compared to the current individual CEO approach.

The second limitation is that this research required transforming several key variables to meet model assumptions, which introduced challenges to interpretation. Thirdly, the dependent variable might not fully capture the additional knowledge creation resulting from CVC investments, as this may manifest in ways other than patenting. Also, this research assesses patenting output up to three years after investments are made. Despite Dushnitsky and Lenox (2005b) suggesting that this time frame encapsulates the strongest effect of patenting output, it cannot be ruled out that some innovation effects might take longer to come into play, potentially limiting the current results. Lastly, this research has a relative broad scope, however further research could focus by researching firms in the high-tech industry, due to firms in this industry having a high likelihood of patenting their innovation, potentially yielding more accurate results (Cloodt et al., 2006; Aalbers et al., 2021; Fontana et al., 2013).

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Appendices

Appendix A: Descriptive statistics before transformation

Table 5

Descriptive statistics before transformation

	N	Mean	SD	Min	Median	Max	Skewness	Kurtosis
Firm innovation	8420	913.556	3020.649	1	55	55407	8.547	113.919
CVC investments	1964	12.335	282.639	0	.013	11152.105	33.952	1268.024
Ownership stake	2859	25.203	13.592	0	24.628	49.99	.219	2.002
CEO age	7394	55.426	7.318	30	56	95	.156	4.022
CEO tenure	17878	5.006	5.304	0	3.447	60.172	2.541	14.007
CEO educational level	15862	17.288	2.262	12	18	21	-.286	3.423
Firm size	21937	31796.2	91420.637	0	7562	2300000	14.053	298.284
R&D expenditure	11762	102.832	3531.996	-.02	2.05	220316.13	48.136	2533.281
Industry relatedness	3052	.608	0.480	0	1	1	-.44	1.23

Appendix B: Correlation matrix

Table 6

Correlation matrix

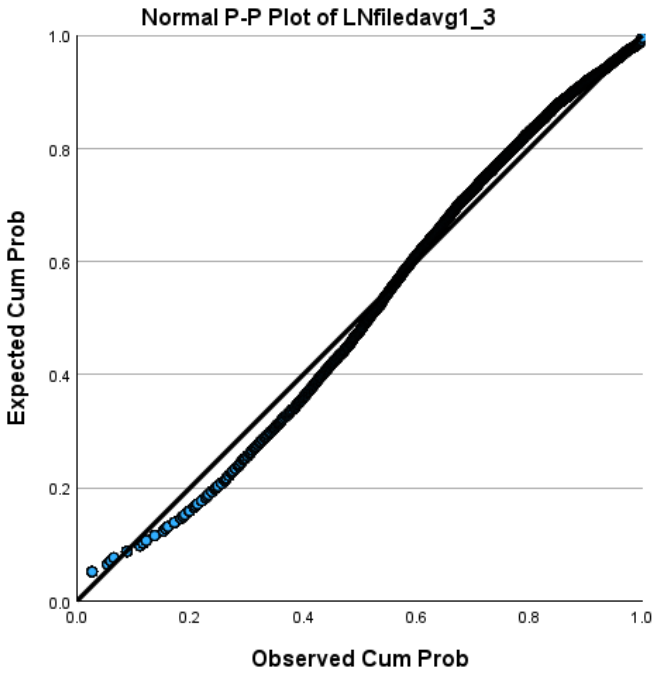
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Firm innovation	1.000								
(2) CVC investments	-0.193***	1.000							
(3) Ownership stake	0.019	-0.027	1.000						
(4) CEO age	-0.039*	-0.087*	0.067*	1.000					
(5) CEO tenure	-0.076***	-0.093***	0.015	0.278***	1.000				
(6) CEO educational level	0.062***	0.004	-0.017	0.098***	-0.030***	1.000			
(7) Firm size	0.461***	-0.412***	0.056***	0.085***	-0.023***	-0.010	1.000		
(8) R&D expenditure	0.112***	0.348***	-0.118***	-0.124***	0.042***	0.135***	-0.277***	1.000	
(9) Industry relatedness	-0.014	0.083***	0.029	-0.019	-0.009	-0.001	-0.075***	-0.023	1.000

**** p<0.01, ** p<0.05, * p<0.1*

Appendix C: P-Plot

Figure 2

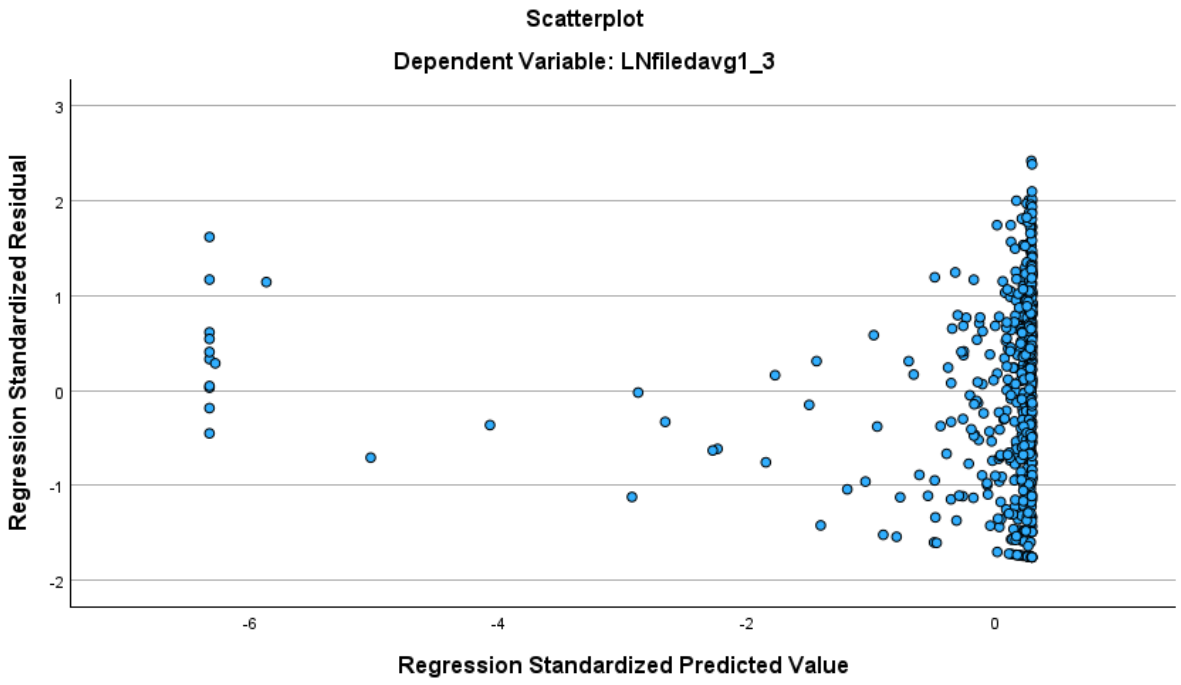
P-Plot



Appendix D: Scatterplot

Figure 3

Scatterplot



Appendix E: VIF scores

Table 7
VIF model 3

	VIF	1/VIF
CVC investments	1.271	.787
Ownership stake	1.287	.777
CVC*Ownership stake	1.264	.791
Firm size	1.16	.862
R&D expenditure	1.234	.811
Industry relatedness	1.056	.947

Table 8
VIF model 4

	VIF	1/VIF
CVC investments	1.772	.564
CEO tenure	1.375	.727
CVC*CEO tenure	1.734	.577
Firm size	1.191	.84
R&D expenditure	1.305	.766
Industry relatedness	1.109	.901

Table 9
VIF model 5

	VIF	1/VIF
CVC investments	4.548	.22
CEO educational level	1.74	.575
CVC* CEO educational level	4.186	.239
Firm size	1.313	.762
R&D expenditure	1.409	.71
Industry relatedness	1.16	.862

Table 10
VIF model 6

	VIF	1/VIF
CVC investments	4.823	.207
CEO age	2.866	.349
CVC*CEO age	4.93	.203
Firm size	1.642	.609
R&D expenditure	1.539	.65
Industry relatedness	1.482	.675

Appendix F: Specifying base model

Table 11
Specifying base model

VARIABLES	(1) LNpatentfiledF2	(2) LNpatentfiledF2	(3) LNfiledavg1_2	(4) LNfiledavg1_2	(5) LNfiledavg1_3	(6) LNfiledavg1_3
CVC investments		1.076**		1.037***		0.851**
		(0.496)		(0.349)		(0.341)
Ownership stake						
CVC*Ownership stake						
Firm size	0.723**	-0.162	0.387**	-0.152	0.249***	0.166***
	(0.281)	(0.350)	(0.190)	(0.300)	(0.0845)	(0.0542)
R&D expenditure	0.191***	0.220***	0.238***	0.265***	0.195***	0.196***
	(0.0686)	(0.0575)	(0.0638)	(0.0580)	(0.0623)	(0.0638)
Industry relatedness	0.0457	-0.0284	0.0401	0.0798	-0.0150	0.0889
	(0.133)	(0.136)	(0.0964)	(0.105)	(0.0903)	(0.0832)
CEO tenure						
CVC*CEO tenure						
CEO educational level						
CVC*CEO educational level						

Constant	-2.148	6.159*	0.876	5.746**	2.365***	3.003***
	(2.688)	(3.373)	(1.792)	(2.862)	(0.824)	(0.573)
Observations	421	276	504	332	541	356
R-squared	0.536	0.590	0.518	0.638	0.523	0.628
Number of isin	293	199	345	237	362	252
Year fe	yes	yes	yes	yes	yes	yes
firm fe	yes	yes	yes	yes	yes	yes

Reported R^2 is the within R^2, reflecting variation explained within firms over time

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix G: Within- and between-firm variation analysis

Table 12

Model 1 controls

```
. xtsum LNfiledavg1_3 LNEMP RD_INT_w industryrelatedness_ratio
```

Variable		Mean	Std. dev.	Min	Max	Observations
LNfile~3	overall	4.151063	2.543448	0	10.92246	N = 8420
	between		2.556418	0	10.85595	n = 1064
	within		.5342942	-.6453929	6.511934	T = 7.91353
LNEMP	overall	8.615297	2.312822	0	14.64842	N = 21937
	between		2.382496	0	14.53686	n = 1676
	within		.4991111	1.455101	14.8861	T-bar = 13.0889
RD_INT_w	overall	4.857012	6.734689	0	24.78	N = 11762
	between		6.564063	0	24.78	n = 1040
	within		1.870521	-14.26499	24.75968	T-bar = 11.3096
indust~o	overall	.6075748	.479539	0	1	N = 3052
	between		.4523323	0	1	n = 1840
	within		.2443618	-.2813141	1.464718	T-bar = 1.6587

Table 13

Model 2 base model

```
. xtsum CVC_INT_w_c CVC_INT_w_c_sq
```

Variable		Mean	Std. dev.	Min	Max	Observations
CVC_IN~c	overall	7.87e-10	.3189116	-.1250669	1.243523	N = 1964
	between		.3473632	-.1250669	1.243523	n = 1294
	within		.1055548	-.6983271	1.165735	T-bar = 1.51777
CVC_IN~q	overall	.1016528	.3469754	3.76e-09	1.54635	N = 1964
	between		.3828493	4.10e-08	1.54635	n = 1294
	within		.1198243	-.7282898	1.446401	T-bar = 1.51777

Table 14

Model 3 ownership stake

```
. asdoc xtsum finalstake_avg_c CVCxfinstake, append
```

Variable		Mean	Std. dev.	Min	Max	Observations
finals~c	overall	1.27e-07	13.59234	-25.20311	24.78689	N = 2859
	between		12.85742	-25.20311	24.78689	n = 1740
	within		7.478519	-29.78825	35.19	T-bar = 1.6431
CVCxfi~e	overall	-.1212544	4.371457	-30.59454	30.58681	N = 1910
	between		4.865145	-29.63081	30.58681	n = 1257
	within		1.530709	-13.92554	19.15147	T-bar = 1.51949

Table 15

Model 4 age

```
. xtsum ceo_age_c CVCxceo_age
```

Variable		Mean	Std. dev.	Min	Max	Observations
ceo_ag~c	overall	-4.67e-08	7.318051	-25.42575	39.57425	N = 7394
	between		6.440595	-22.42575	30.57425	n = 639
	within		4.748817	-23.47619	26.76471	T-bar = 11.5712
CVCxce~e	overall	-.0969276	1.646281	-10.47762	11.55835	N = 427
	between		1.827131	-10.47762	11.55835	n = 319
	within		.3206772	-2.927391	1.560328	T-bar = 1.33856

Table 16

Model 5 tenure

```
. xtsum LNceotenurefocal_c CVCxceotenurefocal
```

Variable		Mean	Std. dev.	Min	Max	Observations
LNceot~c	overall	1.12e-09	.7803372	-1.4851	2.628598	N = 17878
	between		.5577148	-1.4851	2.362694	n = 1549
	within		.6070857	-2.623314	2.201228	T-bar = 11.5416
CVCxce~l	overall	-.0199127	.2368897	-1.846756	1.633212	N = 1332
	between		.2573114	-1.846756	1.633212	n = 894
	within		.0893874	-1.021544	.8415916	T-bar = 1.48993

Table 17

Model 6 educational level

```
. xtsum ceo_amount_education_c CVCxceoedu
```

Variable		Mean	Std. dev.	Min	Max	Observations
ceo_am~c	overall	-9.41e-09	2.261978	-5.287542	3.712457	N = 15862
	between		1.949671	-5.287542	3.712457	n = 1401
	within		1.272978	-7.6	8.4	T-bar = 11.3219
CVCxce~u	overall	.0029059	.6737561	-6.575182	4.616527	N = 1153
	between		.7183048	-6.575182	4.616527	n = 778
	within		.257584	-2.483451	3.812171	T-bar = 1.48201

Appendix H: Hausman test

Table 18

Hausman test

```
. hausman fe re
```

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
CVC_INT_w	1.044731	-.079619	1.12435	1.791594
finalstake~g	-.0005923	-.0005443	-.000048	.002049
LNEMP	-.7693222	1.092917	-1.862239	.4385899
RD_INT_w	.3461801	.1464961	.1996839	.0896856
industryre~o	.3038868	.3308578	-.0269709	.0897807

b = Consistent under H0 and Ha; obtained from **xtreg**.
B = Inconsistent under Ha, efficient under H0; obtained from **xtreg**.

Test of H0: Difference in coefficients not systematic

chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 20.98
Prob > chi2 = 0.0008