Corporate Venture Capital and R&D Investment: An Empirical Analysis Based on the Organizational Learning

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Abstract: This paper investigates the effect of corporate venture capital (CVC) on the initiator company's R&D investment. Using data from A-share listed companies from 2009 to 2016 in China, we find that CVC promotes R&D investment. Besides, the effect of CVC on R&D investment is influenced by industry-related factors; specifically, it is more pronounced in companies that conduct a major business-oriented venture capital. Further tests show that the association between CVC and R&D investment is stronger when the company operates in a high-tech industry, is located in a more developed region and is non-state-owned. Furthermore, the unique characteristics of CVC indicate that both a longer CVC duration and a greater number of CVC capitalists facilitate the association between CVC and R&D investment. Our study suggests that the organizational learning mechanism among CVC participants impacts the initiator company's R&D investment. The findings have meaningful implications for listed companies in promoting R&D investment through organizational learning from CVC activities.

Keywords: Corporate Venture Capital; R&D Investment; Organizational Learning; High-Tech Industry

1. Introduction

Venture capital has become a crucial driving economic force. Corporate venture capital (CVC), as a special organizational form of venture capital, refers to non-financial companies making minority equity investments directly or indirectly in start-up companies [1]. These investing companies participate in real economic activities and establish mechanisms through equity investments to acquire knowledge and technologies from start-up companies, thereby facilitating organizational learning [2]. Compared with independent venture capital (IVC), which mainly consists of traditional financial institutions, CVC exhibits higher efficiency in resource allocation. For example, in terms of patent output, the technological alignment between investment entities and start-up companies in CVC makes CVC more effective in promoting innovation than IVC [3]. This partially explains why CVC has become a common phenomenon in China's capital market. According to the statistics in the paper, 145 listed companies invested 32.4 billion in venture capital funds in 2016. As investment entities, listed companies extensively participate in CVC activities, providing a good scenario for research on the economic consequences of organizational learning.

Listed companies can obtain accurate knowledge of emerging technologies and markets through CVC activities [4]. But, how is the value of these technologies and knowledge resources reflected? The R&D investment of listed companies reflects their choices and priorities in resource allocation models. On the one hand, R&D activities are characterized by high uncertainty and risk, so in R&D activities, companies are required to collect increasingly diverse information to stay updated on the latest technological trends that support R&D decisions [5]. The technology and knowledge resources acquired through CVC activities may help reduce decision-making costs in R&D and give priority to R&D in their resource allocation. On the other hand, R&D activities extend beyond internal companies and collaboration on technology and product development [6]. Organizational learning mechanisms in CVC enable investing companies to engage in organizational learning through project collaboration, researcher exchanges, and by learning about key technologies through board positions. These interactions promote corporate R&D investment by conducting intensive R&D interaction, improving R&D efficiency and increasing expected R&D returns. Therefore, CVC may have a significant effect on corporate R&D activities.

This paper uses data from A-share listed companies (excluding the financial industry) from 2009 to 2016 to empirically study whether CVC promotes corporate R&D investment. The results indicate that CVC companies have significantly higher R&D investment than non-CVC ones, and this effect is robust. However, the promoting effect of CVC on R&D investment disappears when CVC funds are invested in areas unrelated to the main business of the listed companies. The regression results remain robust after the exclusion of potential endogeneity issues through propensity score matching (PSM) and the Heckman two-stage method. Moreover, further research has shown that CVC has a significant positive effect on R&D investment for listed companies in high-tech industries, located in highly marketized regions, and ultimately privately controlled. In terms of CVC activities, the positive correlation between CVC and corporate R&D investment becomes more significant when the CVC fund has a longer duration and more investors.

The possible contributions of this paper are as follows: (1) Unlike existing literature that examines the effect of R&D investment factors, corporate governance characteristics, and institutional environment on R&D activities from the perspective of a single company, this paper focuses on the influence of organizational learning - such as knowledge flow and technological cooperation among multiple stakeholders in CVC - on R&D activities. The findings indicate that CVC promotes corporate R&D investment through organizational learning, enriching the literature in this field from a new research perspective. (2) This study found that CVC can promote a company's R&D investment, enriching existing research on the economic consequences of CVC. (3) The promoting effect of CVC on R&D investment is only observed when CVC is directed toward areas related to the main business of the listed companies, suggesting indiscriminately following the CVC trend does not improve resource allocation efficiency. Only CVC related to the main business can promote R&D investment, a finding that also provides a reference for regulatory policies and norms.

2. Literature Review and Research Hypotheses

2.1 Literature Review

Researches on venture capital, particularly Corporate Venture Capital (CVC), in foreign companies primarily focuses on two aspects: investment motivation behind CVC and its resource allocation efficiency. Researches based on questionnaire surveys show that CVC mainly serves strategic objectives, with a small amount driven by financial motivations. In a study by Yost and Devlin, 93% of companies in the sample indicated that their CVC investments aimed at strategic objectives. The core of these strategic objectives is to establish relationships with technologically leading startups through CVC, thereby enhancing innovation capabilities through learning, interaction, and cooperation [7,8]. Many well-known companies (such as Intel, Siemens, etc.) consider CVC an important part of their innovation strategies. In addition, seeking merger and acquisition opportunities is an important motivation for CVC [9]. The second is the resource allocation efficiency of CVC. Overall, CVC improves resource allocation efficiency. CVC activities are positively correlated with the corporate market value [2] and bring good financial returns [1]. CVC, as a special form of corporate investment, includes multiple entities such as investing companies, start-up companies, and financial intermediaries. Thus, Keil [7] introduced organizational learning theory into CVC research. Social interaction is central to the organizing learning mechanisms between investing companies and start-ups. In CVC activities, investing companies and start-ups acquire knowledge and technologies through social interaction [10]. Investing companies establish various mechanisms to learn from start-ups, including project cooperation, researcher exchange and by learning about key technologies through board positions [2]. A large body of literature has also confirmed that CVC can increase patent production and improve innovation performance through organizational learning [8,11]. Moreover, factors such as intellectual property protection, the business relationship between CVC-invested companies and start-ups, and the ability to acquire knowledge all affect the efficiency of organizational learning [12]. Research has also focused on performance differences between CVC and IVC [3].

In recent years, with a large number of listed companies in China's capital market engaging in CVC, scholars have also begun to pay attention to this field, focusing on CVC performance, the information disclosure of CVC among listed companies, as well as the effect of CVC and IVC on the innovation capability of IPO companies and on IPO underpricing.

R&D investment is characterized by high uncertainty and investment risks [13]. From the perspective of corporate resource allocation, a company's R&D investment reflects its priorities and trade-offs in resource allocation models. Obviously, resource factors directly impact a company's R&D investment. A large body of literature has focused on the effect of factor resources on corporate R&D investment. R&D investment is not limited to the companies. Companies also collaborate on technology development or R&D product [7]. Through inter-organizational learning, companies can promote technological development. Research by Uzzi [14] empirically confirmed that inter-organizational learning significantly promotes knowledge transfer. Companies acquire technology and knowledge from start-ups through organizational learning to generate spillover effects, increase expected R&D returns, reduce R&D costs and bolster R&D enthusiasm, thus promoting greater R&D investment. Many studies have validated the positive effect of inter-organizational learning on corporate R&D [15,16]. Evidently, inter-organizational learning is also an important mechanism that affects a company's R&D investment.

2.2 Research Hypotheses

Previous literature has shown that organizational learning can enhance the R&D performance of companies [15,17]. Companies make R&D investment decisions by collecting a large amount of technical information and knowledge to stay abreast of the latest technological trends [5]. Organizational learning promotes knowledge learning and technological interaction [18], allowing companies to gain a clearer understanding of new product markets and technology trends, thereby providing a stronger foundation for R&D. This reduces R&D uncertainty and risks, increases expected R&D returns, and promotes greater R&D investment. Organizational learning enables communication mechanisms between research personnel and promotes project cooperation among business departments, which improves R&D efficiency, reduces R&D costs, and enhances expected R&D utility, thereby promoting R&D investment.

From a global perspective, CVC helps investing companies gain significant strategic value [8,19]. CVC activities involve multiple entities, such as investing companies, start-ups, financial intermediaries and joint investors, creating the best "stage" for organizational learning. Therefore, the strategic value of CVC comes from investing companies learning from start-ups with abundant innovation resources through organizational learning.

On the one hand, investing companies obtain accurate knowledge of emerging technologies and markets through CVC, which significantly reduces costs related to their R&D activities and brings "delayed income" to corporate investors. This, in turn, lowers R&D costs, increases expected R&D returns, and promotes further R&D investment. On the other hand, organizational learning in CVC includes exploratory learning and developmental learning. The former helps companies innovate and expand business boundaries, while the latter optimizes existing technologies and products [5,11]. CVC encourages investing companies to take a more proactive approach to R&D activities, thereby promoting R&D investment. Therefore, CVC may affect corporate R&D investment through the following channels:

Firstly, companies make R&D investment decisions by collecting a large amount of technical information and knowledge to grasp the latest technological trends [5]. In CVC, investing companies establish various mechanisms to learn and interact with start-ups [20]. For example, investing companies acquire external knowledge and cutting-edge technologies through project cooperation and researcher exchanges and by learning about key technologies of start-ups through board positions [12]. In addition, a form of interaction called "knowledge marketplace" has emerged, where investing companies organize discussions among start-up companies in their investment portfolios to address issues of concern and technology, thereby promoting knowledge transfer and learning [21]. CVC reduces R&D uncertainty and risk through knowledge and technology accumulation, enhances the likelihood of R&D decision-making, and promotes R&D investment.

Secondly, the knowledge-mediating role of relevant departments and personnel in companies after CVC investment is crucial. According to social network theory, knowledge mediation can facilitate knowledge transfer and innovation by bridging gaps in the network. CVC-related departments and personnel bridge two inter-organizational domains and two intra-organizational domains, promoting the transfer and acquisition of technology and knowledge. This adjustment of social networks enhances the role of social capital after investment [22]. CVC-related departments and personnel can even establish network connections between investing companies, invested companies and third parties to create social capital and trigger knowledge and technology transfer [21]. Therefore, through CVC investment, the knowledge-mediating mechanism promotes knowledge and technology transfer through social networks, optimizes R&D efficiency, and thus promotes corporate R&D investment.

Based on the above analysis, this paper proposes the following hypotheses:

Hypothesis 1: Assuming all other conditions remain constant, CVC promotes corporate R&D investment.

Organizational learning theory suggests that a higher knowledge correlation between partners promotes the digestion of knowledge [23]. When CVC is invested in areas related to the main business of a listed company, there is a certain degree of commonality and knowledge complementarity between the investing companies and start-ups, which facilitates interaction and promotes the absorption of knowledge and technologies [20]. CVC related to the main business can help investing companies accumulate knowledge, identify technologies, reduce R&D costs and uncertainties and increase expected R&D returns, thus promoting R&D investment. In CVCs related to the main business, the high business correlation between investing companies and start-ups is conducive to project cooperation and mutual exchange among researchers, resulting in more organizational learning. This enables the transfer of knowledge and technologies, which in turn promotes corporate R&D investment. Thus, we propose the second hypothesis.

Hypothesis 2: Assuming all other conditions remain constant, only CVC invested in areas related to the main business can promote corporate R&D investment.

3. Research Design

3.1 Sample Selection and Data Sources

The research samples in this paper consist of A-share listed companies on the Shanghai and Shenzhen stock markets from 2009 to 2016. The data on the CVC of the listed companies mainly comes from the PEVC database of Wind Information. Specifically, data on venture capital funds established and raised by listed companies between 2009 and 2016 were extracted from the PEVC database and then classified and summarized manually. Firstly, venture capital funds established with the participation of listed companies in the financial industry were excluded. Secondly, data from non-venture capital funds, such as real estate project investment and PPP project investment, were excluded. For example, the Zhonggong Wuhan Urban Development Fund, established with the participation of Zhonggong International (002051. SZ), which invested in the PPP project for municipal construction and road support, was excluded.

In addition, the initial data was processed as follows: (1) financial and insurance companies were excluded; (2) ST and PT companies were excluded; (3) companies with missing data for variable calculations were excluded. The financial data for the remaining companies in this study was obtained from the CSMAR database. A 1% Winsorization was conducted for all continuous variables to eliminate the interference of outliers. Moreover, based on Petersen's [24] method, a white heteroscedasticity robustness correction was applied to the standard errors of all regression models. Clustered standard errors at the company level were also performed due to the use of panel data with a short sample period and a large number of cross-sectional samples.

3.2 Measurement of Core Variables

3.2.1 R&D investment

Regarding the definition of corporate R&D investment, this paper uses the ratio of R&D investment to main business income as a measure of R&D investment intensity (R&D1). Considering the effect of company size on R&D investment, the ratio of R&D investment to the company's net assets is used as a second indicator of R&D investment intensity (R&D2).

3.2.2 CVC

According to Wind database, we capture CVC data with the investment amount, investment term, joint investors, investment scope, and so on. For example, Daan Gene (002030. SZ) established the Daan Medical Fund with a fund size of 303.05 million yuan and a duration of 8 years. This industrial investment fund mainly focuses on innovative small, medium and micro enterprises in Guangzhou's professional incubators, operated and managed by Daan Gene or its affiliates, as well as other companies in the emerging medical and health industry in Guangzhou. Whether a listed company made CVC is coded as a dummy variable: if the company made a CVC investment, it is coded as 1 starting from the year of investment; otherwise, it is coded as 0.

3.2.3 Control variables

Based on existing research, this paper controls for the effects of the following factors: company size (Size), financial leverage (Lev), Return on asset (Roa), growth ability (Growth), shareholding ratio of the largest shareholder (Top1), board size (Boardsize), company cash flow (Cfops), and nature of actual controller (Soe).

In addition, year and industry effects are controlled for as well. The specific definitions and measurements of the main variables are shown in **Table 1**.

Table 1. Definition and Measurement of Main Variables

Variable Name	Symbol	Definition and measurement of variables
R&D investment	*R&D1* *R&D2*	1) Ratio of R&D investment to sales revenue 2) Ratio of R&D investment to net assets
Corporate venture capital	*CVC*	Does a listed company invest in establishing a venture capital fund. If a listed company participates in the establishment of a venture capital fund, the CVC value for the year of establishment and subsequent years is 1, otherwise it is 0.
Company size	*Size*	Equal to the natural logarithm of the company's total assets.
Financial leverage	*Lev*	Represents the level of a company's liability, which is equal to the ratio of its total liabilities to total assets.
Return on asset	*Roa*	Return on total assets
Growth ability	*Growth*	The growth rate of the main business
Shareholding ratio of the largest shareholder	*Top1*	The shareholding ratio of the largest shareholder
Board size	*Boardsize*	The natural logarithm of the total number of board members
Company cash flow	*Cfops*	Net cash flow from operating activities per share.
Nature of actual controller	*Soe*	Virtual variable, 1 for the state-owned actual controller, and 0 for the non-state-owned

3.3 Model Construction

The following models were constructed to verify the hypotheses.

$$R\&D = \alpha_0 + \alpha_1 CVC + \sum_{q=2}^{m} \alpha_q (q\ th\ Controls) + Year + Ind + \varepsilon \quad (1)$$

$$R\&D = \alpha_0 + \alpha_1 MaRelVC + \alpha_2 Non\_MaRelVC + \sum_{q=3}^{m} \alpha_q (q\ th\ Controls) + Year + Ind + \varepsilon \quad (2)$$

Model (1) tests for hypothesis 1, where R&D is the dependent variable representing corporate R&D investment, measured by R&D1 and R&D2, respectively. CVC is the explanatory variable, representing whether the listed company participates in the establishment of venture capital. Model (2) tests hypothesis 2, where MaRelVC represents venture capital related to the main business of the listed company, and Non_SaRelVC represents venture capital unrelated to the main business of the listed company. Year and Ind represent the fixed effects for year and industry, respectively. Since the dependent variables in both model (1) and model (2) are continuous and greater than or equal to 0, the Tobit regression model is used for estimation based on the model property. According to hypothesis 1, the coefficient of CVC is expected to be significantly positive. According to hypothesis 2, the coefficient of MaRelVC is expected to be positive and significantly greater than the coefficient of Non_ SaRelVC.

4. Empirical Results

4.1 Descriptive Statistics of Major Variables

The descriptive statistical results of the main variables in this paper are shown in **Table 2**. The overall R&D investment of listed companies is as follows. The mean value of R&D1, measured as the proportion of R&D investment to main business income, is 2.519, while the ratio of R&D2 to net assets has a mean of 2.938. The standard deviations of the two indicators are 3.367 and 5.068, respectively, indicating certain differences in R&D investment across the sample of listed companies. The mean value for the indicators of whether listed companies participated in CVC is 0.038, with a standard deviation of 0.192. This indicates that approximately 3.8% of listed companies were involved in CVC activities. The statistical results for the other variables are consistent with findings from previous literature and fall within a reasonable range.

Table 2. Descriptive Statistical Results

Variable name	Observation value	Mean value	Median	Standard deviation	Min	Max
R&D1	17021	2.519	1.140	3.637	0	21.15
R&D2	17021	2.938	1.350	5.068	0	35.07
CVC	17021	0.038	0	0.192	0	1
Size	17021	21.95	21.79	1.296	19.03	25.81
Lev	17021	0.453	0.447	0.224	0.045	1.028
Roa	17021	0.037	0.034	0.057	-0.212	0.210
Growth	17021	0.062	0.095	0.322	-1.610	0.851
Top1	17021	35.31	33.34	15.21	8.600	75.92
Boardsize	17021	2.265	2.303	0.178	1.792	2.773
Cfops	17021	0.358	0.269	0.782	-2.276	3.383
Soe	17021	0.434	0	0.496	0	1

4.2 Correlation Analysis of Main Variables

As shown in **Table 3**, the Pearson correlation coefficient and Spearman correlation coefficient between the two R&D investment variables, R&D1 and R&D2, are 0.886 and 0.508, respectively, both positively correlated at the 1% significance level. The strong positive correlation between the two indicators is consistent with expectations, ensuring the appropriateness of the selected indicators. In terms of the correlation between the dependent variables, R&D1 and R&D2, and the independent variable, CVC, the Spearman correlation coefficients are 0.043 and 0.031, respectively, both of which are positively correlated at the 1% level. These results are in line with the research hypotheses, and the Pearson correlation coefficients remain consistent, which verifies the hypotheses through correlation analysis.

Table 3. Correlation Analysis of Main Variables

Variable name	*R&D1*	*R&D2*	*CVC*
R&D1	1	0.886***	0.043***
R&D2	0.508***	1	0.031***
CVC	0.065***	0.065***	1

Note: The upper triangle represents the Spearman correlation coefficient, and the lower triangle represents the Pearson correlation coefficient. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%.

4.3 Differential Test

Table 4 shows the T-test results of listed companies with and without CVC. For the group with CVC = 1 (i.e. listed companies with CVC), the mean values of the two R&D investment indicators, R&D1 and R&D2, are 3.706 and 4.588, respectively, both significantly higher than the values of 2.472 and 2.873 for the group with CVC = 0 (i.e. listed companies without CVC). Both differences are statistically significant at the 1% level, indicating that the R&D activities of listed companies in the CVC group were more active, reflected in higher R&D investment. This preliminary result supports the hypotheses of this paper.

Table 4. Difference Test

Variables	*CVC*=0			*CVC*=1			Mean-Diff	Wald Chi2
	Obs.	Mean	Median	Obs.	Mean	Median		
R&D1	16368	2.472	1.110	653	3.706	1.890	-1.233***	12.214***
R&D2	16368	2.873	1.340	653	4.588	1.630	-1.716***	3.722*
Size	16368	21.93	21.77	653	22.36	22.19	-0.433***	79.220***
Lev	16368	0.454	0.449	653	0.428	0.410	0.025***	7.140***
Roa	16368	0.037	0.034	653	0.041	0.035	-0.005**	0.079
Growth	16368	0.061	0.095	653	0.093	0.106	-0.032**	1.534
Top1t	16368	35.46	33.49	653	31.71	29.80	3.747***	21.988***
Boardsize	16368	2.265	2.303	653	2.262	2.303	0.003	2.355
Cfops	16368	0.359	0.270	653	0.330	0.260	0.029	1.144
Soe	16368	0.439	0	653	0.317	0	0.122***	37.765***

Note: The upper triangle represents the Spearman correlation coefficient, and the lower triangle represents the Pearson correlation coefficient. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%.

4.4 Regression Results

4.4.1 CVC and R&D investment

Table 5 shows the regression results for testing hypothesis H1. Columns (1) and (3) show the regression results without control variables, where the coefficients of CVC and R&D investment (R&D1, R&D2) are significantly positive at the 5% level or higher. Columns (2) and (4) present the regression results after the addition of control variables. The coefficients for CVC are 0.723 and 0.932, respectively, indicating that CVC significantly promotes corporate R&D investment. This result is consistent with the expectations of this paper, verifying hypothesis H1. CVC refers to investing companies learning from start-ups with abundant technological resources, accumulating knowledge and technologies, thus promoting R&D activities. Therefore, CVC improves the efficiency of resource allocation.

Table 5. Test Results of Hypothesis H1

Variable name	*R&D1*		*R&D2*	
	(1)	(2)	(3)	(4)
CVC	0.862***	0.723**	1.030**	0.932**
	(2.676)	(2.381)	(2.293)	(2.108)
Size		0.061		0.192**
		(1.108)		(2.085)
Lev		-5.608***		2.051***
		(-15.318)		(3.751)
Roa		-0.775		5.983***
		(-0.748)		(3.968)
Growth		0.337**		1.143***
		(2.550)		(5.535)
Top1		-0.004		0.009
		(-1.110)		(1.584)
Boardsize		0.260		0.704
		(0.769)		(1.322)
Cfops		-0.055		0.066
		(-0.967)		(0.696)
Soe		-0.646***		-0.048
		(-4.943)		(-0.249)
Constant	-6.149***	-4.512***	-8.765***	-15.806***
	(-12.020)	(-3.519)	(-13.426)	(-7.974)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Firm_Cluster	Yes	Yes	Yes	Yes
Obs.	17021	17021	17021	17021
Pseudo R^2	0.134	0.155	0.084	0.087

Note: The coefficients are estimated using the Tobit model. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%. The T-value during the statistical test underwent White heteroscedasticity robustness correction and cluster at the company level. The T values are in the brackets.

4.4.2 CVC Related to Main Business and R&D Investment

We further classify the investment fields of CVC. If the CVC of a listed company invests in the upstream and downstream sectors of its main business industry chain, MaRelVC is coded as 1, otherwise 0. For example, Daan Gene (002030. SZ), whose main business is biopharmaceuticals, established Daan Medical Fund to invest in companies in the emerging medical and health industry. As this type of CVC is related to the main business, MaRelVC is coded as 1. If the CVC invests outside the upstream and downstream sectors of the main business, NonaMaRelVC is coded as 1, and all other situations are coded as 0. The regression results to test hypothesis 2 are shown in **Table 6**. The column (1) and (3) show the regression results without control variables, revealing that the regression coefficients for MaRelVC and R&D investment (R&D1, R&D2), related to main businesses, are significantly positively correlated at the 1% level. In contrast, the regression coefficients for NonaMaRelVC and R&D investment (R&D1, R&D2) in areas unrelated to the main businesses are not significant. After adding control variables into ther regression model, as is shown in columns (2) and (4), the results remain consistent. The coefficients for MaRelVC and R&D investment (R&D1, R&D2), related to the main business, are both significant at the 1% level. The regression coefficient for NonaMaRelVC is positive, but it does not pass the significance test. Obviously, the regression results in Table 6 verify hypothesis H2. They also confirm the organizational learning theory that a higher correlation of knowledge between collaborators promotes knowledge digestion [23]. Specifically, only CVC investments in areas related to the main business of a listed company can promote R&D investment and improve the efficiency of resource allocation.

Table 6. Test Results of Hypothesis H2

Variable	*R&D1*		R&D2	
	(1)	(2)	(3)	(4)
MaRelVC	1.477^{***}	1.131^{***}	1.304^{***}	1.233^{***}
	(4.200)	(3.434)	(3.506)	(3.391)
Non_MaRelVC	0.425	0.206	0.258	0.271
	(1.519)	(0.795)	(0.849)	(0.893)
Constant	-6.186^{***}	-4.526^{***}	-8.795^{***}	-15.859^{***}
	(-11.984)	(-3.535)	(-13.388)	(-7.993)
Control	No	Yes	No	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Firm_Cluster	Yes	Yes	Yes	Yes
Obs.	17021	17021	17021	17021
Pseudo R^2	0.134	0.156	0.084	0.087
F-statistic (*Prob* > *F*): *MaRelVC* > *Non_ MaRelVC*	0.0165**	0.0236**	0.0240**	0.0355**

Note: The coefficients were estimated using the Tobit model. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%. The T-value during the statistical test underwent White heteroscedasticity robustness correction and cluster at the company level. The T values are in the brackets.

4.4.3 The Effect of Industry and Regional Characteristics

CVC behavior exhibits a characteristic of "options-type" learning, which enables listed companies to obtain multiple options to cope with new technological changes and market uncertainties through minority equity investment [25]. Companies in high-tech industries, which face rapid technological advancements, frequent changes in business models, and greater industry volatility, gain greater option value from CVC. They thus place a greater emphasis on the knowledge and technological accumulation brought by CVC, so their R&D activities may be subject to CVC. In addition, the organizational learning aspect of CVC enables companies to optimize existing products through external knowledge and technological resources [11]. The optimization and improvement activities of high-tech companies require greater R&D investment compared to non-high-tech firms. Therefore, CVC plays a more significant role in promoting R&D investment for these companies. Based on the study in [26], a regression analysis was conducted, with listed companies divided into high-tech industry and non-high-tech groups. The regression results in **Table 7** indicate that the coefficients of CVC for the high-tech industry group on R&D investment are 0.965 and 1.338, respectively, and are significant at the 5% level. In contrast, the regression coefficients for non-high-tech industries do not pass the significance test. The regression data also verifies the hypothesis of this paper. Therefore, the promotional effect of CVC on R&D investment is specific to the high-tech industry.

Table 7. Effect of Industry Characteristics

Variables	High-tech industry		Non high-tech industry	
	R&D1	*R&D2*	*R&D1*	*R&D2*
	(1)	(2)	(3)	(4)
CVC	0.965**	1.338**	0.180	-0.124
	(2.544)	(2.461)	(0.529)	(-0.152)
Constant	6.099***	-5.120**	-8.510***	-25.246***
	(4.190)	(-2.297)	(-4.760)	(-6.480)
Control	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Firm_ Cluster	Yes	Yes	Yes	Yes
Obs.	11699	11699	5322	5322
Pseudo R^2	0.104	0.046	0.138	0.090

Note: The coefficients were estimated using the Tobit model. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%. The T-value during the statistical test underwent White heteroscedasticity robustness correction and cluster at the company level. The T values are in the brackets.

Table 8. Effect of the Regional Marketization Level

Variable	High level of marketization		Low level of marketization	
	R&D1	*R&D2*	*R&D1*	*R&D2*
	(1)	(2)	(3)	(4)
CVC	0.881**	1.452**	0.573	0.384
	(2.201)	(2.319)	(1.303)	(0.675)
Constant	-2.850	-10.426***	-5.823***	-19.529***
	(-1.383)	(-3.017)	(-3.509)	(-7.709)
Control	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Firm_Cluster	Yes	Yes	Yes	Yes
Obs.	7491	7491	9523	9523
Pseudo R^2	0.161	0.095	0.152	0.086

Note: The coefficients were estimated using the Tobit model. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%. The T-value during the statistical test underwent White heteroscedasticity robustness correction and cluster at the company level. The T values are in the brackets.

The "competitive effect" has long been recognized in corporate R&D activities. The higher regional marketization leads to more intense market competition. This competition incentivizes companies to increase R&D investment to maintain their core competitiveness and competitive advantage. Therefore, the level of regional marketization may affect the promotional effect of CVC on R&D investment through product market competition. **Table 8** shows the regression results segmented by marketization level. In areas with high marketization, the regression coefficients of CVC on R&D investment are 0.881 and 1.452, respectively, both significant at the 5% level. However, for regions with low marketization, the regression results do not show significant positive effects. Therefore, the results align with the literature, indicating that CVC promotes R&D investment only in highly marketized areas.

4.4.4 The Effect of Company's Ownership Structure

The ownership structure of a company leads to significant differences in the environment in which organizational learning plays a role. State-owned companies are confronted with more political considerations and tend to have completely different employee incentive mechanisms and work systems compared to private companies, which leads to differences in the efficiency of organizational learning. Therefore, organizational learning in CVC may have different effects on resource allocation and promotional effects on R&D investment. Considering the effect of ownership structure, a regression analysis was conducted, with companies grouped into state-owned and private sectors. The results in **Table 9** indicate that the CVC regression coefficients for the private companies are 0.971 and 1.343, respectively, both significant at the 1% level. However, the CVC coefficients for state-owned companies do not pass the significance test. This indicates that the promotional effect of CVC on R&D investment exists only in private companies, which is consistent with the logic that organizational learning is more effective in the flexible system of private companies, thereby enhancing the promotional effect of CVC on R&D investment.

Table 9. Effect of Ownership Structure

Variables	State-owned companies		Private companies	
	R&D1	*R&D2*	*R&D1*	*R&D2*
	(1)	(2)	(3)	(4)
CVC	0.142	0.006	0.971***	1.343***
	(0.331)	(0.008)	(2.842)	(2.634)
Constant	-4.352***	-17.479***	-4.839**	-14.856***
	(-2.801)	(-5.620)	(-2.555)	(-5.821)
Control	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Firm_Cluster	Yes	Yes	Yes	Yes
Obs.	7385	7385	9636	9636
Pseudo R^2	0.165	0.111	0.135	0.071

Note: The coefficients were estimated using the Tobit model. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%. The T-value during the statistical test underwent White heteroscedasticity robustness correction and cluster at the company level. The T values are in the brackets.

5. Further Analysis

5.1 Duration of Venture Capital Funds

The main motivation for CVC is to bring strategic value to companies [19]. This type of CVC focuses more on actions that deliver long-term value to start-ups, such as learning technologies and knowledge, rather than on short-term financial gains [2]. Thus, in CVC, venture capital funds aimed at strategic objectives have longer durations. Subsequently, the effect of venture capital fund duration on R&D investment was investigated, and the regression results in **Table 10** show that the regression coefficients of duration on R&D investment were positive, with values of 0.192 and 0.455, respectively, passing the significance test at the 1% level. Therefore, the longer the duration of the venture capital fund established in CVC, the more it promotes corporate R&D investment, which is consistent with the strategic motivation for CVC in the literature.

Table 10. Effect of the Duration of Venture Capital Funds

Variable	*R&D1*	*R&D2*
	(1)	(2)
Duration	0.192***	0.455***
	(6.171)	(8.860)
Constant	-30.837***	-99.813***
	(-119.910)	(-230.067)
Control	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
Firm Cluster	Yes	Yes
Obs.	448	448
Pseudo R^2	0.177	0.090

Note: The coefficients were estimated using the Tobit model. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%. The T-value during the statistical test underwent White heteroscedasticity robustness correction and cluster at the company level. The T values are in the brackets.

5.2 Number of Investors in Venture Capital Funds

Organizational learning in CVC is, to some extent, based on the social network constructed by investment behavior. Social network theory suggests that CVC stakeholders act as knowledge mediators, thereby promoting knowledge transfer and innovation by bridging structural gaps in the social network [27]. Moreover, CVC stakeholders help optimize and establish new networks by promoting social network restructuring to facilitate technology transfer and knowledge acquisition [22]. Therefore, the effect of the number of CVC investors (Cap-Num) on R&D investment was investigated by collecting information on the number of CVC investors. The regression results are displayed in **Table 11**. It was found from the regression analysis that the more CVC investors (Cap-Num), the greater the promotional effect on R&D investment, which is consistent with social network theory.

Table 11. Effect of Number of Investors

Variable	*R&D1*	*R&D2*
	(1)	(2)
Cap_Num	1.277**	1.643**
	(2.334)	(2.030)
Constant	0.525	-23.509*
	(0.075)	(-1.703)
Control	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
Firm_Cluster	Yes	Yes
Obs.	595	595
Pseudo R^2	0.162	0.087

Note: The coefficients were estimated using the Tobit model. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%. The T-value during the statistical test underwent White heteroscedasticity robustness correction and cluster at the company level. The T values are in the brackets.

6. Robustness Test

6.1 Endogenous Issues

Firstly, there may be systematic differences between listed companies that have established venture capital and those that have not, and they may interfere with the regression results in this paper. To alleviate this issue, the nearest neighbor matching in PSM was selected to pair companies with and without venture capital in a 1:1 ratio, after which the main tests were conducted. Referring to existing literature, matching was based on factors such as company size, return on asset, liability level, main business growth rate, largest shareholder ownership, board size, net cash flow per share from operating activities, and industries. This yielded 653 experimental groups with venture capital and 653 control groups without. The regression results after PSM, shown in **Table 12**, indicate the CVC coefficient remains significantly positive, which confirms the robustness of the main conclusion drawn in this paper.

Table 12. PSM Regression Results

Variable	*R&D1*		*R&D2*	
	(1)	(2)	(3)	(4)
CVC	1.074***	0.729**	0.783	0.926*
	(2.736)	(2.131)	(1.464)	(1.792)
Size		-0.035		-0.021
		(-0.205)		(-0.071)
Lev		-4.784***		5.713***
		(-3.487)		(3.091)
Roa		1.806		14.074**
		(0.464)		(2.312)
Growth		1.467***		1.614*
		(2.856)		(1.687)
Top1		-0.026**		-0.023
		(-2.093)		(-1.380)
Boardsize		-0.924		1.113
		(-0.813)		(0.625)
Cfops		-0.260		-0.086
		(-1.375)		(-0.273)

Soe		-0.580		-0.112
		(-1.566)		(-0.185)
Constant	-6.530***	0.412	-11.691***	-15.319**
	(-4.113)	(0.098)	(-5.043)	(-2.174)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Firm_Cluster	Yes	Yes	Yes	Yes
Obs.	1306	1306	1306	1306
Pseudo R^2	0.142	0.159	0.088	0.093

Note: The coefficients were estimated using the Tobit model. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%. The T-value during the statistical test underwent White heteroscedasticity robustness correction and cluster at the company level. The T values are in the brackets.

Table 13. Heckman Two-stage Regression Results

Variable	*R&D1*		*R&D2*	
	Stage 1	Stage 2	Stage 1	Stage 2
	(1)	(2)	(3)	(4)
CVC		0.258**		0.826**
		(2.179)		(2.181)
Lev		-1.925***		1.197***
		(-11.593)		(2.671)
Top1		0.001		0.011**
		(0.414)		(2.478)
Boardsize		0.256*		0.621
		(1.763)		(1.520)
Soe		-0.215***		-0.144
		(-3.789)		(-0.961)
Size	0.115***	-3.017***	0.133***	-2.128***
	(6.937)	(-59.924)	(8.701)	(-15.135)
Roa	0.837**	-21.388***	0.552	-5.634***
	(2.104)	(-33.750)	(1.486)	(-3.966)
Cfops	-0.065**	1.725***	-0.064***	1.080***
	(-2.569)	(44.662)	(-2.705)	(11.216)
Growth	0.031	-1.252***	0.060	0.164
	(0.477)	(-13.542)	(0.959)	(0.761)
R&D1_lag1	0.022**		-0.000	
	(2.522)		(-0.043)	
R&D1_lag2	0.009		0.013*	
	(0.818)		(1.773)	
R&D1_lag3	0.003		0.025***	
	(0.355)		(3.566)	
IMR		-30.684***		-19.808***
		(-70.770)		(-18.764)
Constant	-5.209***	155.702***	-4.862***	82.922***
	(-12.575)	(67.118)	(-13.193)	(15.079)
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
Firm_Cluster	Yes	Yes	Yes	Yes
Obs.	17061	16909	17061	16909
Pseudo R^2	0.107	0.277	0.045	0.103

Note: The coefficients were estimated using the Tobit model. ***, * *, * respectively indicate passing the test at significance levels of 1%, 5%, and 10%. The T-value during the statistical test underwent White heteroscedasticity robustness correction and cluster at the company level. The T values are in the brackets.

Secondly, the decision of listed companies to establish venture capital is self-selected rather than randomly assigned, so the Heckman two-stage model was used to mitigate the effects of venture capital motivation and other unobservable factors, alleviating the potential interference of self-selection bias on the conclusions drawn in this paper. In the first stage, a Probit estimation model was constructed for the establishment of venture capital by a listed company. This model included variables such as company size, return on assets, net cash flow per share from operating activities, main business growth rate, R&D investment in the previous period, R&D investment in the two preceding periods, R&D investment in the three preceding periods, as well as year and industry factors. From this, the inverse Mills ratio (IMR) was calculated. In the second stage, the inverse Mills ratio was added to the main regression as a control variable. The regression results are shown in **Table 13**, which suggests that after controlling for possible self-selection issues, the coefficient of CVC remains significantly positive in the second stage, indicating that the main regression results in this paper remain constant.

6.2 Other Robustness Tests

Other robustness tests were conducted to ensure the reliability of the research results.

Firstly, financial crises can impact the investment strategies of listed companies. Therefore, data from 2009 was excluded from the sample. After the main regression was re-run, the results remained constant.

Secondly, Petersen [24] suggests that standard errors were adjusted through two-way clustering at both individual and temporal levels to overcome issues of heteroscedasticity and autocorrelation in statistical inference. Based on Petersen's [24] method, standard errors adjusted by two-way clustering were used in the t-test to ensure the robustness of the conclusions of this paper. When the main regression was with these adjustments, the results remained consistent.

7. Conclusion

Based on the organizational learning theory, this paper systematically examines the effect of CVC on the R&D investment of investing companies. According to data from A-share listed companies from 2009 to 2016, the study finds that CVC promotes the R&D investment of the investing companies. This promoting effect exists only when CVC is invested in areas related to the companies' main business. Since Keil initially introduced the organizational learning theory into CVC research [11], a large amount of research has confirmed that organizational learning promotes knowledge acquisition and technology transfer in CVC activities [20]. Knowledge and technology are often closely related to R&D activities, as confirmed by the research conclusions of this paper. Organizational learning in CVC promotes R&D investment by the investing companies themselves. The theory of organizational learning suggests that a high correlation of knowledge between partners enhances the digestion of knowledge [23], which is consistent with the theoretical hypothesis of this study. This study finds that the promoting effect of CVC on R&D investment is significant in companies with CVC related to their main business. In addition, groups such as high-tech industries, regions with high marketization, and private companies, as well as CVC funds with longer durations and more investors, have a more significant impact on R&D investment. These factors affect the efficiency of organizational learning in CVC, thereby affecting R&D investment. For example, state-owned companies face greater political costs and have fundamentally different employee incentive mechanisms and work systems compared to private companies. These differences lead to variations in organizational learning efficiency and, thus, to different effects of CVC on R&D investment. Therefore, the key to promoting R&D investment through CVC lies in organizational learning mechanisms and efficiency.

The findings of this paper have important policy implications for the regulation of CVC in listed companies. In recent years, CVC has become increasingly common in China's capital market, but many speculative behaviors are driven by indiscriminate trend-following behaviors and the speculation of the secondary market. These behaviors can be detrimental to investors' interests. This study shows that CVC has a promotional effect on R&D investment in investing companies, with the organizational learning mechanism as the key. This effect is particularly strong in companies with CVC invested in areas related to their main businesses. Therefore, when formulating CVC regulations, regulatory authorities can take into account the investment scope, as doing so could enhance the resource allocation efficiency of CVC. In addition, the findings also have practical significance for listed companies in improving their CVC activity efficiency. The promoting effect of CVC on R&D investment is more significant in environments where organizational learning mechanisms are more efficient. To take advantage of this effect, listed companies can enhance the promoting effect of CVC on R&D investment and increase investment value by improving their employee incentive mechanisms, scientific research cooperation and exchange, awareness of knowledge and technology learning, and the efficiency of organizational learning mechanisms in their CVC operations. Evidently, further regulation and guidance of CVC are necessary to improve its resource allocation efficiency.

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