



The effect of state-owned venture capital on enterprise innovation: Evidence from China

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ABSTRACT

Venture capital (VC) funded by state-owned enterprises constitutes a significant component of China's state-owned capital (SOC) investment. This paper empirically investigates the impact of state-owned venture capital (SOVC) on enterprise innovation and identifies that SOVC exerts a more pronounced influence on enhancing enterprise innovation capability. SOVC facilitates the enhancement of enterprise innovation capability by alleviating financial constraints, fostering joint investments, and attracting technical talents. This paper not only aids in identifying effective approaches to advance SOC reform but also contributes to enhancing enterprise innovation capability through the utilization of SOC.

1. Introduction

China's restructuring of SOC has enhanced the evolution of its management structure and operational mechanisms. The State-Owned Assets Supervision and Administration Commission (SASAC) has transitioned from a previous role of direct control to overseeing and managing SOC operating companies. This reform has separated the functions of operation and management from SOC, leading to a distinct segregation of responsibilities related to overseeing personnel, operations, and capital within state-owned enterprises. As a pivotal component of the experimental reforms in SOC investment and operations, SOVC maintains the traditional policy-driven attributes while also embodying the profit-oriented characteristics typical of general VC. This duality not only preserves the unique features of SOC but also fosters a more market-driven approach to capital management. Consequently, a comprehensive examination is imperative to understand the impact of SOVCs on enterprise innovation post-reform, given its significance in enterprise financing.

There are many literatures explore the correlation between VC institutions and enterprise innovation. These studies demonstrate that VC can enhance innovation capabilities by providing value-added services in science, technology, and investment, meeting enterprises' capital requirements (Cavallo et al., 2019; Andrusiv et al., 2020; Pradhan et al., 2020; Li et al., 2022; Zhang et al., 2024a). However, contrasting views exist regarding how different types of VC influence technological innovation within enterprises. Some research suggests that state-owned VC contributes to enhancing enterprises' innovation capacity (Liegsalz & Wagner, 2013; Bernstein et al., 2016; Vanderhoven et al., 2020; Shao & Sun, 2021; Battisti et al., 2022; Wu et al., 2023; Zhang et al., 2024b), while others argue that government-backed institutions often struggle to grasp pertinent enterprise information, leading to a limited impact on innovation (Cochrane, 2005; Chemmanur et al., 2011; Nishimura & Okamuro, 2011; Zuo et al., 2017; Wu et al., 2020). Therefore, it is imperative

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to investigate whether a more market-oriented approach in SOVC post-reform can significantly influence enterprise innovation systematically.

In this paper, an empirical analysis was conducted using data from China's A-share listed companies spanning 2011 – 2020 to examine the influence of SOVC on enterprise innovation. The findings indicate a significant enhancement in the technological innovation capabilities of enterprises due to SOVC. This impact is attributed to several mechanisms, including the alleviation of financing constraints, the establishment of joint investment mechanisms, and the facilitation of talent attraction for enterprises. Furthermore, the paper categorizes listed companies based on their alignment with government-supported industries and investigates the heterogeneous innovation effects of SOVC.

The paper's contribution lies in three key areas. Firstly, it examines the impact of market-oriented SOVC on enterprise innovation post SOC reform, investigating whether the level of marketization influences the innovation incentive efficacy of such investments. Secondly, it demonstrates that a more market-oriented approach to SOVC can boost enterprise innovation levels, offering insights for SOC reforms globally. Lastly, the paper delves into the precise mechanisms through which SOVC influences enterprise innovation, laying the groundwork for enhancing the innovation promotion efficacy of such investments.

The remainder of this paper is organized as follows. Section 2 describes the econometric model and data; Section 3 presents the empirical results and robustness checks; and Section 4 concludes.

2. Empirical model and data

2.1. Empirical model

In order to quantify the extent to which SOVC institutions promote the innovation ability of enterprises, this paper establishes the following empirical model:

$$Livent_{it} = \beta_0 + \beta_1 VCnature_{it-1} + \beta_2 CStruct_{it-1} + \beta_3 LAsset_{it-1} + \beta_4 Grow_{it-1} + \beta_5 ROE_{it-1} + Firm_i + Year_t + \varepsilon_{it} \quad (1)$$

Eq. (1) is established to verify the influence of state-owned VC institution intervention (VCnature) on enterprise innovation (LInvent). Eq. (1) Both the intervention variables and control variables of China's capital VC have a lag effect on the impact of enterprise innovation, so both need to lag one order. In addition, the control variables that reflect enterprise management, such as asset structure, enterprise scale, net profit growth rate and ROE, will also have a lag effect on asset structure and enterprise scale, so the control variables also need to lag one order. We include year and firm fixed effects in Eq. (1).

2.2. Data

This paper focuses on Chinese A-share listed companies spanning from 2011 – 2020. It excludes underperforming ST companies, financial institutions, and entities with significant data gaps, resulting in an empirical analysis involving 3,493 listed companies as the research sample. Data sources for VC characteristics include verification from the Zero2IPO Private Equity database, Tianyancha database, and prospectuses. For VC indicators not available in databases, manual searches are conducted in the enterprise prospectuses and the official websites of VC institutions. The determination of joint investment from VC institutions in an enterprise hinges on identifying if more than two VC entities appear among the top ten shareholders. Table 1 shows variable definitions and summary statistics for reference.

3. Results and discussion

3.1. Baseline results

Table 2 shows the benchmark regression findings of this paper, validating the impact of SOVC on enterprise innovation. The first column's regression outcomes indicate that enterprises backed by SOVC institutions exhibit a superior level of technological innovation capability compared to those lacking such investments. In the second column, the regression equation adjusts for the influence of VC on enterprise innovation, revealing a consistently positive and significant coefficient for SOVC. This reaffirms the heightened efficacy of SOVC in enhancing enterprise innovation ability relative to non-state-owned counterparts.

Table 1
Variable definitions and summary statistics.

Variable name	Variable defines	Sample size	Mean	Standard deviation	Max	Min
Invent	Number of invention patent applications and authorizations	12192	84.12	896.12	4799	0
RDinput	Innovation input	7386	9.60	282.90	2572.39	0
VC	Venture capital	12192	0.371	0.52	1	0
VCnature	State-owned venture capital	9052	0.061	0.24	1	0
Fcash	Free cash flow	12192	7.3e+6	3.2e+9	1.7e+11	-8.3e+10
Unite	Joint investment	11808	0.37	0.50	1	0
RDpeople	Number of R&D personnel	1123	625.83	2466.52	88533	0
Gover	Government policy support	7851	0.42	0.49	1	0

Table 2
The impact of state-owned VC on enterprise innovation.

	(1) LInvent	(2) LInvent
VCnature	0.797*** (8.604)	0.252*** (3.531)
VC		0.337*** (12.667)
CStruct	-0.001 (-.989)	-0.005*** (-3.745)
LAsset	0.283*** (10.212)	0.333*** (7.043)
Grow	0.001** (-2.374)	0.001** (-1.962)
ROE	-0.002* (-1.74)	-0.002 (-1.347)
Constant	-3.648*** (-6.456)	-4.489*** (-4.53)
Fixed Effects	Yes	Yes
Observations	9052	9052
R-squared	0.077	0.187

Note: Values in parentheses are t-statistics corrected for heteroscedasticity; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

3.2. Mechanism examination

We use a two-stage mediation effect model to examine three impact mechanisms of SOVC on enterprise innovation capability.

3.2.1. Ease financing constraints mechanisms

SOVC exhibits robust financial strength, a solid capital chain, higher tolerance for enterprise innovation failures, and a focus on long-term enterprise outcomes. Consequently, the entry of state-owned VC institutions is more likely to mitigate the issue of inadequate R&D funding for innovative enterprises and bolster their innovation capabilities. Within the regression model, LFcash denotes the logarithm of enterprises' free cash flow. Table 3's first two columns investigate the mechanism of alleviating financing constraints through SOVC. The findings in the first column indicate that enterprises benefiting from VC involvement witness a significant increase in free cash flow compared to those without such partnerships, thereby easing the financing constraints they face. As illustrated in the second column's regression results, the mechanism of mitigating corporate financing constraints acts as a partial intermediary in the VC regression that drives corporate innovation. Hence, SOVC fosters enterprise innovation by addressing the financing challenges encountered by invested firms.

3.2.2. Joint investment mechanism

SOVC institutions not only retain the investment advantages of conventional risk institutions but also amplify the "endorsement effect" of the government. This release of a more potent positive spillover effect extends to external investors, attracting state-owned

Table 3
The mechanisms of state-owned VC on enterprise innovation.

	(1) LFcash	(2) LInvent	(3) Unite	(4) LInvent	(5) LRDpeople	(6) LInvent
VCnature	0.447*** (10.861)	0.228** (2.533)	0.316* (1.852)	0.281*** (6.816)	0.382*** (6.526)	0.393*** (5.706)
LFcash		0.139* (1.879)				
Unite				0.039*** (3.451)		
LRDpeople						0.009*** (4.842)
Constant	6.353*** (2.939)	5.822** (2.212)	-0.008 (-.061)	-0.001 (-1.27)	-4.966* (-1.725)	-4.816*** (-5.104)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9052	9052	9052	9052	1123	1123
R-squared	0.034	0.129	0.102	0.099	0.082	0.079

Note: Values in parentheses are t-statistics corrected for heteroscedasticity; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

banks, other financial institutions, and VC firms to provide financing or equity funding for target enterprises, thereby securing additional external financial support for the invested businesses. Columns 3 and 4 in Table 3 scrutinize the collaborative investment mechanism of SOVC. The regression outcomes in these columns demonstrate that SOVC enhances the innovation capabilities of enterprises through this joint investment mechanism.

3.2.3. Talent introduction mechanism

Based on the endorsement effect exerted by state-owned VC institutions, state-owned VC holds greater appeal to external talents seeking entry into enterprises due to its policy advantages and national standing compared to regular VC entities. The regression findings in columns 5 and 6 of Table 3 indicate that the presence of state-owned VC substantially enhances enterprises' ability to attract innovative talents. The variable representing talent recruitment acts as a partial intermediary in the pathway through which state-owned VC drives enterprise innovation. These results validate that SOVC enhances enterprises' technological innovation capabilities by drawing in external R&D personnel.

3.3. Endogeneity test

As there could be a causal link between SOVC and enterprise innovation, the entry of SOVC institutions may genuinely stimulate enterprise innovation through mechanisms such as alleviating corporate financing constraints, engaging in joint investments, and attracting talents. However, VC institutions might also select investment targets based on the independent innovation capabilities of enterprises. Consequently, this paper's model may encounter endogeneity issues, leading to estimation result biases. To assess the potential impact of endogeneity on this paper's findings, the model is further examined using the Propensity Score Matching Method. Following matching, a total of 6968 samples were obtained from the experimental group and the control group, with Table 4 presenting the balance of the main matching variables.

The matched samples underwent regression analysis once more, with the results displayed in the first column of Table 5. Based on the regression outcomes presented in the table, the coefficient associated with the participation of SOVC institutions exhibits a notably positive value. This finding validates that investments from SOVC can effectively enhance the innovation capacity of invested enterprises post-matching, affirming the persistence of the hypothesis even after addressing the endogeneity concern discussed in the paper.

3.4. Heterogeneity test

The findings presented in the second column of Table 5 indicate that when enterprises are backed by state-owned VC institutions and operate within industries supported by government policies, the interaction terms between state-owned VC institutions and policy support exhibit a notably enhanced impact on the technological innovation capabilities of these enterprises. This outcome validates that if enterprises operate within government-supported industries, state-owned VC institutions play a more potent role in fostering innovation capabilities.

3.5. Robustness test

In this paper, the level of innovation investment replaces the count of invention patents, and a robust test is conducted. The regression outcomes of the robustness test outlined in Table 6 indicate that state-owned VC institutions exert a significantly more pronounced impact on the augmentation of enterprise innovation input. This finding substantiates that state-owned VC institutions yield a more substantial effect on enhancing the innovation level of enterprises, thereby affirming the continued validity of the three previously established mechanisms. The results presented in Table 6 validate the robustness of the empirical test findings in this paper.

4. Conclusion

The empirical findings of this paper demonstrate that the reform of China's SOC enhances the degree of marketization within SOVC, subsequently leading to a significant enhancement in the innovation capabilities of the recipient enterprises. The three mechanisms through which SOVC fosters the advancement of enterprises' innovation capabilities encompass providing more ample

Table 4
Logit regression results and matching balance table of main variables

Variables	Category	Treatment group	Control group	%bias	T-Value	P-Value
CStruct	Before matchmaking	37.1	44.7	-37.9	-21.7	0
	After matchmaking	37.1	43.5	0.2	0.1	0.9
LAsset	Before matchmaking	20.8	21.3	-30.6	-17.5	0
	After matchmaking	20.8	20.8	2.7	1.6	0.1
Grow	Before matchmaking	28.4	25.0	1.2	0.7	0.5
	After matchmaking	28.4	24.3	1.5	0.9	0.4
ROE	Before matchmaking	11.7	12.6	-4.1	-2.3	0
	After matchmaking	11.7	12.9	-3.1	-1.8	0.1

Table 5
Endogeneity test and heterogeneity test.

	(1) LInvent	(2) LInvent
VCnature	0.297*** (10.199)	0.233*** (6.268)
VCnature*Gover		0.112*** (7.745)
Constant	-3.329*** (-4.889)	-3.398*** (-4.134)
Control variables	Yes	Yes
Fixed effects	Yes	Yes
Observations	6968	7851
R-squared	0.124	0.104

Note: Values in parentheses are t-statistics corrected for heteroscedasticity; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 6
Robustness test.

	(1) RDinput	(2) LFcash	(3) RDinput	(4) Unite	(5) RDinput	(6) RDinput	(7) LRDpeople	(8) RDinput
VCnature	0.265*** (25.59)	0.383*** (6.526)	0.161*** (6.831)	0.265*** (25.59)	0.128*** (7.037)	0.407*** (8.717)	0.155*** (4.612)	0.176*** (10.187)
VCnature *LFcash			0.012** (2.027)					
VCnature *Unite					0.107** (2.032)			
VCnature *LRDpeople							0.017** (2.472)	
VCnature *Gover								0.043** (2.041)
Constant	1.366*** (4.096)	-1.025 (-1.292)	1.028*** (3.55)	0.153** (2.464)	1.235*** (4.567)	-6.246*** (-8.693)	1.275** (2.526)	6.348*** (5.308)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7386	7386	7386	7386	7386	1069	1069	6792
R-squared	0.025	0.261	0.032	0.149	0.028	0.354	0.033	0.251

Note: Values in parentheses are t-statistics corrected for heteroscedasticity; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

and stable funds to alleviate financing constraints, exerting an "endorsement" influence on the invested enterprises to attract additional VC institutions for collaborative investments, and aiding in talent attraction for innovative endeavors. Moreover, the research identifies that the positive impact of SOVC on enterprise innovation is particularly pronounced within industries that receive government policy support.

The paper's conclusions yield three significant policy implications. Primarily, the distinction between the nature of VC and the enhancement of enterprise innovation primarily manifests in the marketization level of VC operations. Therefore, endeavors should focus on elevating the marketization level of SOVC, enabling it to select investment targets with greater flexibility and precision. Secondly, there should be a concerted effort to leverage the "endorsement" role of SOVC, utilizing the signal of such investment to assist enterprises in attracting additional financial and talent support. Lastly, when nations employ financial instruments to implement industrial support policies, they may consider integrating financial subsidies with SOC risk investment to enhance the execution efficiency of industrial support policies.

CRediT authorship contribution statement

Chenyang Yu: Writing – original draft, Funding acquisition, Formal analysis. **Mengke Wang:** Writing – original draft, Data curation. **Changluan Fu:** Writing – review & editing, Formal analysis. **Jinbo Song:** Writing – review & editing, Methodology, Data curation.

Declaration of competing interest

The authors declare no conflict of interest.

Data availability

The authors do not have permission to share data.

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