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The heterogeneous impact of CVC and IVC on enterprise innovation: Based on empirical evidence from Chinese A-share listed companies

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Abstract: *Based on the resource-based view and agency theory, this study investigates the differentiated impact of corporate venture capital (CVC) and independent venture capital (IVC) on enterprise innovation ability in three steps. In the first step, taking China's A-share listed companies from 2020 to 2024 as a sample, the number of patent applications is used to measure innovation output, and the innovation effect of CVC and IVC is empirically tested through the panel random effects model, and it is found that the promotion effect of CVC on innovation is significantly better than that of IVC, and there is no significant difference between hybrid investment (MIX) and CVC. In the second step, the scale of the enterprise and the asset-liability ratio are introduced as moderating variables, and it is found that the scale positively adjusts the innovation effect of CVC, while the high asset-liability ratio will weaken the positive impact of CVC. The results show that the innovation level of all enterprises has risen steadily, but the growth slope of enterprises supported by CVC is steeper, showing a continuous differentiation pattern. This study provides new evidence for the financing decision-making of innovative enterprises and the strategic positioning of venture capital institutions.*

Keywords: *Corporate venture capital; Independent venture capital; Enterprise innovation; Moderating effect; Panel data*

1. Introduction

In the context of the interweaving of scientific and technological revolution and industrial transformation, innovation has become the source of the core competitiveness of enterprises. As a bridge connecting capital and innovation, venture capital plays an irreplaceable role in cultivating technology-based enterprises. However, venture capital is not homogeneous: corporate venture capital (CVC) is established by industrial enterprises and has both strategic and financial goals [1]; Independent venture capital (IVC) focuses on financial returns and has a specialized governance mechanism [2]. The difference in resource endowment and investment logic between the two types of capital may profoundly affect the innovation path of the invested enterprises [3].

There are differences in the existing research conclusions on the innovation effects of CVC and IVC [4]. Some scholars believe that CVC's industrial collaboration can improve innovation quality [5], but some studies point out that IVC's financial discipline is more conducive to innovation efficiency [6]. In China's unique institutional environment, the registration system reform provides a new channel for venture capital exit, and it is urgent to carry out systematic testing based on the latest data [7].

In order to bridge the research gap, this paper is developed in three steps. In the first step, using the balance panel data of A-share listed companies from 2020 to 2024, a random-effect model was constructed to test the differentiated impact of CVC and IVC on innovation output (number of patent applications) [8]. In the second step, the scale of the enterprise and the asset-liability ratio are introduced as moderating variables to explore the contingency effect of the two on the relationship between VC type and innovation [9][10]. The third step is to reveal the macro time trend through the year fixation effect, and compare the dynamic evolution trajectory of enterprise innovation in the context of the three types of VC [11][12]. The study used the CSMAR database to divide the samples into three groups: CVC, IVC, and hybrid (MIX), with a total of 884 listed companies (4420 observations) according to the nature of the top two shareholders at the time of listing [13]. The innovation of this paper is that the latest data after the full implementation of the registration system is

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used to systematically reveal the adjustment mechanism of enterprise scale and financial leverage, and deepen the understanding of the long-term enabling effect of CVC through dynamic trend analysis. The research conclusions have implications for corporate financing strategies, differentiated competition of investment institutions, and policy optimization [14].

2. Model creation, solution and discussion

2.1. Model establishment

In this section, three econometric models are constructed according to the research steps, corresponding to the first step of benchmark testing, the second step of moderating effect analysis and the third step of dynamic trend investigation.

2.1.1. Baseline panel model

To test the average impact of different venture capital types on corporate innovation, the following benchmark regression model is established:

$$Innovation_{it} = \alpha_0 + \beta_1 IVC_{it} + \beta_2 MIX_{it} + \sum \gamma_k Controls_{itk} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Among them, the interpreted variable $Innovation_{it} = \ln(Patent_{it} + 1)$, the patent data comes from CSMAR; The core explanatory variables are VC type virtual variables, with CVC as the benchmark, IVC and MIX as dumb variables. The control variables include asset-liability ratio (debt), return on net assets (ROE), company size ln_{size}, enterprise age $firm_{age}$ and year dummy variables; μ_i and λ_t are individual and time effects, respectively. The model form was determined by the F-test, LM test, and Hausman test, and the results supported the random-effects model.

2.1.2. Moderating effect model

In order to investigate the moderating effect of enterprise size and asset-liability ratio on the relationship between VC type and innovation, an interactive term is introduced on the basis of model (1):

$$\begin{aligned} Innovation_{it} &= \alpha_0 + \beta_1 IVC_{it} + \beta_2 MIX_{it} + \beta_3 (IVC \times Moderator_{it}) + \\ &\beta_4 (MIX \times Moderator_{it}) + \sum \gamma_k Controls_{itk} + \mu_i + \lambda_t + \varepsilon_{it} \end{aligned} \quad (2)$$

Among them, Moderator stands for ln_{size} (company size) and debt (asset-liability ratio) respectively. At the same time, group regression (high and low groups by median) was used as a robustness supplement.

2.1.3. Dynamic trend and grouping model

In order to capture the dynamic changes in the temporal dimension and the differentiation trend between VC groups, the coefficient series of year dummy variables were focused on on the basis of model (1), and the time trend of each VC subsample was estimated separately:

$$Innovation_{it} = \alpha_0 + \sum_{t=2021}^{2024} \theta_t Year_t + \sum \gamma_k Controls_{itk} + \mu_i + \varepsilon_{it} \quad (3)$$

The CVC, IVC, and MIX sub-sample estimation models (3) were compared with the differences in the fixed effect coefficients θ_t of the years to reveal the innovative growth paths of enterprises with different VC backgrounds.

2.2. Model Solution and Results

2.2.1. Step 1 model solution results

Table 1 descriptive statistics show that the average number of patent applications of the sample enterprises is 507.38 and the standard deviation is 895.29, indicating that the innovation output is heterogeneous. Figure 1 showed that CVC, IVC, and MIX accounted for 33.3%, 32.8%, and 33.9%,

ISSN 2616-5902 Vol. 8, Issue 8: 44-50, DOI: 10.25236/AJBM.2026.080806

respectively, with a balanced balance between groups. The kernel density plot in Figure 2 shows that the logarithmic distribution pattern of the three groups is similar, but the box plot in Figure 3 shows that there are more high-value outliers in the CVC and MIX groups, which initially suggests that CVC may have given birth to more high-yield innovators.

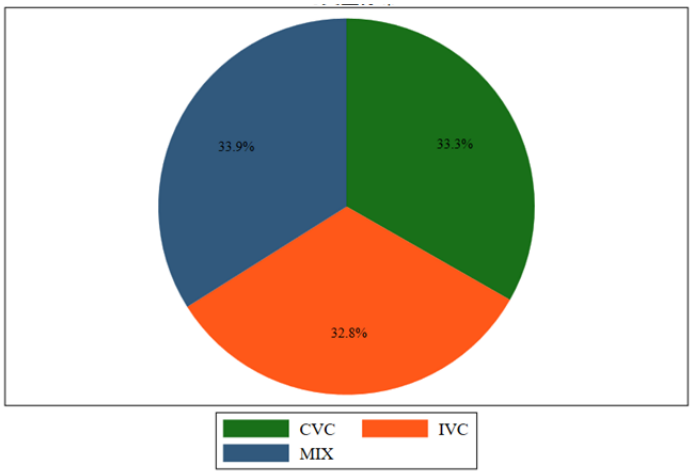

Figure 1 VC type distribution pie chart.

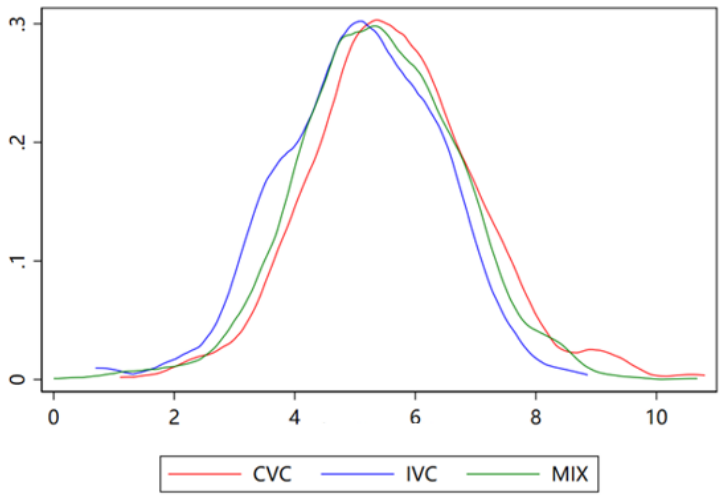

Figure 2 Patent distribution density kernel density graph for different VC types of companies.

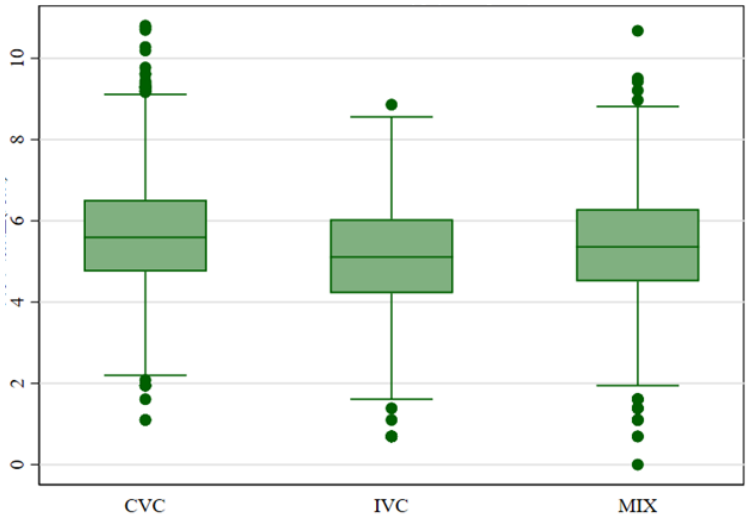

Figure 3 Box plot of the distribution of patent applications under different VC types.

ISSN 2616-5902 Vol. 8, Issue 8: 44-50, DOI: 10.25236/AJBM.2026.080806

Table 1 Optimal strategy key coordinates

Variable	mean	sd	min	max
ln_patent	5.377	1.358	0	11
patent	507.384	895.291	0	6211
debt	0.303	0.167	0	1
roe	0.056	0.121	-6	1
ln_size	21.447	0.990	19	27
firm_age	7734.98	2133.49	3213	24471
Observations	4420			

The estimation results of the random-effects model are shown in Table 2. Based on CVC, the coefficient of IVC is -0.307 ($p<0.01$), indicating that the number of patent applications supported by IVC is about 26.5% lower than that of CVC. The MIX coefficient was not significant, indicating that there was no significant difference between hybrid investment and pure CVC. Among the control variables, ln_size was significantly positive (0.435), debt was significantly positive (0.332), and the dummy variables of the year increased significantly.

Table 2 Optimal strategy key coordinates

Variable	Coefficient	Standard Error
IVC	-0.307***	(0.091)
MIX	-0.055	(0.090)
debt	0.332***	(0.094)
roe	0.032	(0.062)
ln_size	0.435***	(0.026)
firm_age	-0.000***	(0.000)
Constant term	-3.617***	(0.584)
R^2 overall	0.283	

The results are shown in Table 3 below, the IVC coefficients are -0.198 and -0.183 (both $p<0.01$), the MIX is not significant, the confidence intervals of the three model coefficients overlap.

Table 3 Optimal strategy key coordinates

Variable	Negative biallom regression	Panel Tobit
IVC	-0.198*** (0.049)	-0.183*** (0.043)
MIX	-0.023 (0.047)	0.029 (0.041)

2.2.2. Step 2 model solution results

According to the group regression results in Table 4, the IVC coefficient was -0.410 ($p<0.01$) in the large enterprise group, and the absolute value was greater than that in the small enterprise group (-0.241, $p<0.05$). The IVC coefficient of the high debt group was not significant, while the low debt group was significantly negative (-0.392, $p<0.01$). This shows that the advantages of CVC are more prominent in large enterprises and low-debt enterprises. Figure 4 shows that the three curves under the high debt level are approaching, weakening the difference in VC types and supporting the negative adjustment of the asset-liability ratio.

Table 4 Optimal strategy key coordinates

Grouping	IVC coefficient	Standard error	Observation
Small companies	-0.241**	(0.118)	2210
Large companies	-0.410***	(0.130)	2210
Low debt	-0.392***	(0.113)	2210
High debt	-0.189	(0.115)	2210

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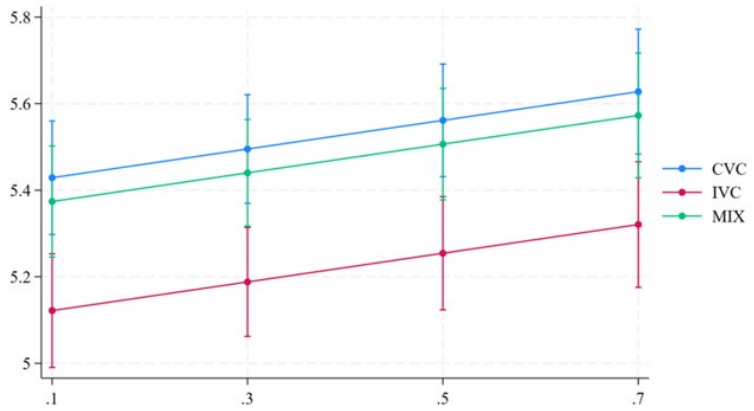

Figure 4 VC type marginal effect (different levels of debt) line chart.

2.2.3. Step 3 model solution results

Figure 5 illustrates the annual fixed-effect time trend of innovation levels across the full sample, with coefficients rising from 5.0 to 5.6 between 2020 and 2024, reflecting the overall effectiveness of macro-level innovation incentive policies. Figure 6 further breaks down patent filing trends by VC type, revealing that while CVC patent filings surged from approximately 480 to 880, IVC filings only increased from about 250 to 440, indicating that the innovation promotion effect driven by CVC is continuous and cumulative. Finally, Figure 7 presents the marginal effects for different VC types, showing that the predicted innovation levels for both CVC and MIX are significantly higher than that of IVC, thereby statistically corroborating the unique long-term enabling value of CVC.

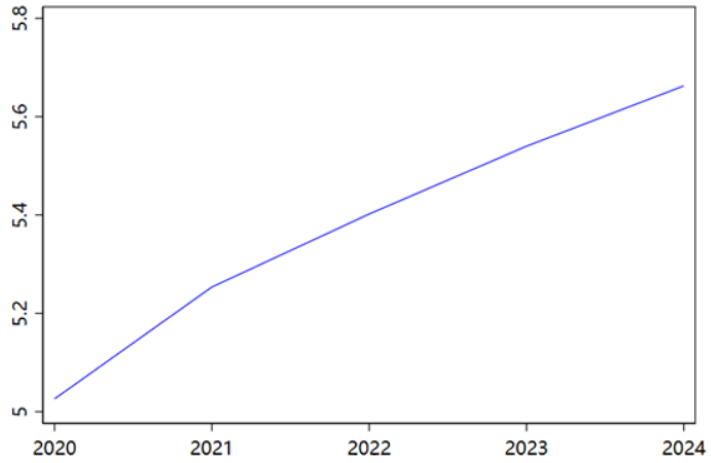

Figure 5 Year fixed effect (time trend) line chart.

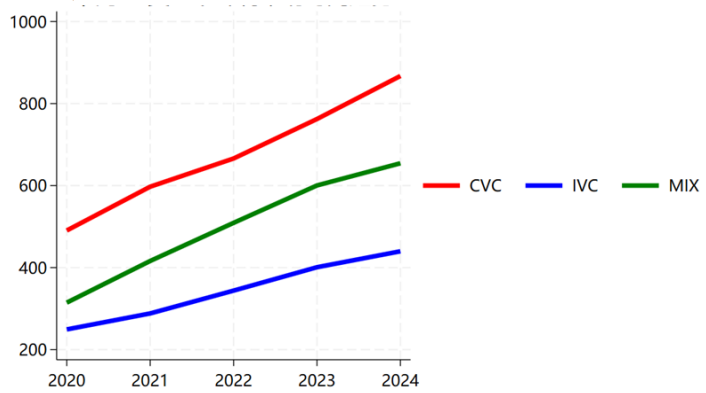

Figure 6 of patent filing time trend under different VC types.

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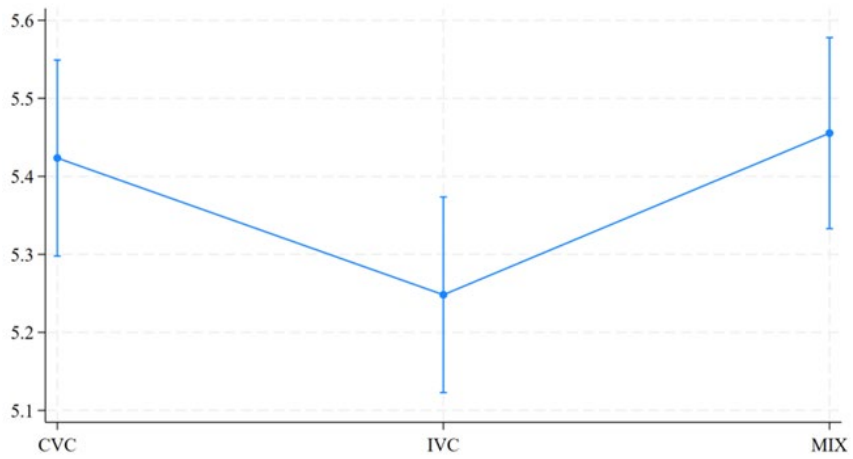

Figure 7 Line plots of marginal effects for different VC types.

2.3. Results and discussion

The above empirical results systematically reveal the differentiated impact of CVC and IVC on enterprise innovation and its boundary conditions. The first benchmark regression confirms the expectation of the resource-based view: CVC significantly improves the innovation output of invested enterprises through industrial resource synergy, while IVC's financial orientation fails to produce the same effect. The second step adjustment effect shows that the scale of enterprises enlarges the resource absorption capacity of CVC, while the financial leverage constrains its long-term innovation investment, which is in line with the contingency theory. The third step of dynamic analysis further shows that the innovation advantages of CVC accumulate over time and form a continuous differentiation pattern. The research conclusions have important implications for enterprises to choose venture capital types, to build differentiation capabilities of investment institutions, and for policymakers to optimize the venture capital ecosystem.

3. Conclusion

Based on the data of China's A-share listed companies from 2020 to 2024, this paper systematically examines the differentiated impact and adjustment mechanism of CVC and IVC on enterprise innovation ability from the perspective of resource basis and agency theory. The core findings are as follows: First, the patent application volume of CVC-supported enterprises is significantly higher than that of IVC-supported enterprises, and the hybrid investment (MIX) effect is not significantly different from CVC, indicating that CVC can promote innovation more effectively by virtue of industrial resource synergy. Second, the scale of the enterprise positively adjusts the innovation effect of CVC, and the larger the scale, the more prominent the advantages of CVC; The asset-liability ratio is negatively adjusted, and high debt will weaken the positive role of CVC, and financial constraints may become an innovation bottleneck at this time. Third, the time trend analysis shows that the innovation level of all enterprises has increased year by year, but the growth slope of the CVC group is steeper, reflecting the cumulative effect of long-term strategic empowerment.

Based on the above conclusions, the following suggestions are put forward: for innovative enterprises, CVC should be prioritized if in-depth industrial resource support is needed, while IVC can be chosen for the pursuit of standardized governance and listing process. Venture capital institutions need to differentiate their competition: CVCs should maintain the autonomy of invested companies and avoid excessive intervention; IVC can strengthen the grafting ability of industrial resources. Policymakers can design precise support policies for different VC types, such as providing tax incentives for long-term investment in CVCs, providing standardized guidance for IVC's governance services, and jointly optimizing the innovative financial ecosystem.

There are certain limitations in this study: the innovation indicator only uses the number of patents, and does not measure the quality in depth (such as patent citation); The classification of VC types is based on static equity at the time of listing and does not reflect dynamic changes. The sample is limited to A-share listed companies, and the conclusion needs to be extrapolated with caution. In the future,

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patent quality indicators can be introduced, dynamically tracking changes in VC shareholdings, and expanded to unlisted companies and cross-border comparisons to deepen the understanding of the relationship between venture capital and innovation.

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