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Analysis of the Investment Activity and Innovative Achievements of Venture Companies in the Context of the Chinese Government's Policy

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Abstract

For our research we chose Chinese GVC as representative data for global venture capital and studied the influence of the Chinese government on enterprise innovations through venture capital institutions against the background of the country's economic and social environment in 2016–2022.

In this paper, we apply regression analysis methods, aiming to study the impact of official venture capital data on the indicators of enterprises' innovation success and to solve the existing problems in related fields. Regression analysis shows that GVC is a significant driver of innovation and has a certain attractive impact on non-GVC. The study demonstrated that direct venture investment has a greater stimulating influence on corporate innovation than the state's implicit price subsidies. Topic studies showed that characteristic features of GVC were aligned with the China's China's macroeconomic development strategy in the investment field and that GVC was region-oriented.

Keywords: Chinese government, venture capital, innovative achievements

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Introduction

In March 2021 the principal goals of social development established for China's 14th five-year plan did not include a specific indicator of increase in investments in research and development (R&D) in the country as a whole, yet the average annual growth in R&D investment exceeded 7%. The target value of GDP growth was over 6%, indicating that an increase in R&D expenses was at least as large as GDP growth, and in the spring China started developing innovations. In 2021 China adopted a series of competition laws and many large internet providers were severely sanctioned. This had a major impact on all spheres of Chinese economy, in particular, it caused a dramatic drop in the Chinese stock market. One of the objectives of governmental market intervention was to prevent the influence of monopoly on the development of innovation in China. The Chinese government clearly assigns high priority to innovation.

Government venture capital is an important part of venture capital. Numerous scientists have studied the influence of GVC on enterprise innovation, yet the majority of research results demonstrate that the role of direct government venture capital is not as significant in investment as that of IVC or PVC. GVC also has a stimulating effect and a crowding-out effect, which have an inverted U-shaped relationship with an increase in the investment amounts, and there are problems that the government cannot alleviate by the lack of ability to assess value. These problems indicate that government bodies are not professional investment institutions. Managerial skills are not among the officials' strong points; therefore, the efficiency of government capital utilization is rather low. In this paper we chose Chinese state venture capital institutions as representative data for GVC, and examined the economic and social environment in the country in 2016-2022 as a background for the study of governmental influence on the innovative achievements of an enterprise through venture capital institutions.

Our goal is to determine the influence of GVC on innovative achievements, improve the knowledge system in this field, offer a new method for the study of the role of government venture capital to corresponding managerial staff and provide effective suggestions for solving the problems that still exist in related fields.

Literature Review

Venture Capital

First, the majority of studies revealed that venture capital plays a prominent part in promotion of innovation in companies. A. Romain & B. Potterie [1] studied the empirical data on the role of venture capital in technology innovation and arrived at the conclusion that venture capital was similar to corporate scientific research and made a significant contribution to the increase in the number of patents, surpassing the effect of corporate scientific research. Yuan Xinming and Zhang Haiyan [2] analyzed the mechanism of the impact of venture capital on innovative development and revealed that venture capital had a greater impact on corporate technology innovation than R&D investment. Zhang Jiefen and Guo Yujie [3] assert that venture capital in China has achieved a certain development level and exerts a significant direct positive influence on the country's scientific and technological innovation potential and economic advance. However, this is a limited effect.

Some studies showed that venture capital had no significant impact on innovation. So, D. Engle and M. Keilbach [4] studied the influence of venture capital on the innovation activity of German companies and discovered that the companies that had obtained venture capital showed higher growth rates, but failed to have significant changes in innovations and worked only at promotion of innovation. H. Lahra and A. Minac [5] used data on 940 companies from Great Britain and the USA for 2002–2004 and discovered that the influence of venture capital on development of corporate technology was insignificant and even negative. Venture capitalists were focused on deriving profit from the already existing technology, rather than obtaining patents and licensing. They assist companies in the use and lean optimization of the existing technology, but may subsequently stand in the way of developing new technology. However, studies showed that venture investment has a positive impact on corporate growth, i.e., commercialization, market share and size.

Empirical research by Yang Yun, Tan Xiangyang and Ran Yui (2019) [6], which used data of high-technology GEM companies for 2011–2016 as an example, showed that venture capital is less efficient in stimulating companies to essential innovation and is more efficient in promoting strategic innovation. Assuming that exogenous innovative opportunities do not change over time, Wang Ting (2016) [7] shows that venture capital in China may have a capital increasing effect on technology innovation, but does not contribute to innovation efficiency. Jun Wen, Di Yang and Geng-Fu Feng believe that venture capital has a positive influence on innovation in China only when investment is significant enough and exceeds the threshold amount. Venture capital may greatly reduce innovation opportunities for the enterprises that obtain investment if the investment scale is relatively small, especially in western provinces and provinces with a lower investment level after dividing the selected provinces into groups [8].

Government Venture Capital

There are three categories of research dedicated to the influence of government venture capital on non-government venture capital.

First, according to signaling theory, GVC produces an introductory effect on IVC or PVC. Jarunee Wonglimpiyarat [9] showed in the paper Government Programmes in Financing Innovations, Comparative Innovation System Cases of Malaysia and Thailand that government support encourages PVC implementation and R&D commercialization, and the government added it to the key strategy of national innovations and development. Besides, F. Bertoni and T. Tykvová [10] studied the question of whether

government venture capitalists (GVCs) are able to drive innovation in the emerging biotechnological industry and discovered that while GVCs have no significant impact on innovation, they may mitigate the influence of independent venture capitalists (IVCs) on inventions and innovation.

Second, when investment institutions have different capital and experience, venture capital influences corporate technology innovation in a different way. Due to the high-risk and long-term nature of investment in innovations, it is more difficult for investment institutions to reach a consensus on fund allocation to corporate innovation.

Third, according to the most widespread opinion, GVC and non-GVC do not merely have a cause-and-effect relationship; they are mutually supportive effects. Literature states that GVC and PVC support corporate innovation activity in different ways: the strong points of GVCs are attributable to their close connections with the government and privileged access to government resources. At the same time, GVCs have numerous weaknesses because they do not have an opportunity to identify projects and manage risks, as venture capitalists do. Therefore, such companies show a lower investment efficiency and decreased independence in decision making. They have to invest together with venture capitalists in order to reduce control risks and improve investment efficiency.

According to Xu Daishen [11], the interrelation between GVC and non-GVC is as follows: on the one hand, venture capital is focused more on innovative projects in order to gain economic benefits, while GVC is focused on strategic significance, long-term development and social benefits of innovative projects. On the other hand, along with financing, venture capital institutions render management services, market consulting services etc. Venture capital and government support of technology innovation influence each other, rather than cancel each other out. When choosing innovative projects, venture capitalists also account for market prospects and assess their commercial value, along with the economic benefits that they will get from them in future (Zi Lei You, 2018) [12]. Their combination may to a certain degree reduce uncertainty that arises due to long R&D cycles, strict technical requirements, a long product gestation period and a long period of return on investment, thus reducing the likelihood of losing viable innovative projects.

Venture capital and government support also have a mutually reinforcing signaling impact on technology innovation. Raising of venture capital means that projects possess innovation potential and allows the state to make a better assessment of their quality and invest government funds in an efficient manner. The interaction between the government and corporate venture capital significantly increases corporate investment in R&D and the number of patents. This indicates that they may be complementary in their support of corporate innovation and jointly provide active support of corporate innovative activity.

There are contradictory conclusions in literature on the influence of GVC on innovation: some research shows that GVC has a significant impact on innovation in companies, while others state that GVC does not have a pronounced impact on innovation, like IVC or PVC, and may even have an adverse effect on innovation.

Government investment is aimed at regulation of market failures, therefore GVC pays more attention to innovation projects that are of strategic significance, provide social benefits and fulfill social needs, but are in conflict with the profit-earning goals in high-tech industries, or in situations when certain industries cannot afford to impose particularly high requirements on capital.

Cui Lin in his paper The Impact of Government Venture Capital on the Performance of Entrepreneurial Enterprises (2018) [13] emphasizes that government venture capital increases start-ups' capacity for growth, but does not increase their profit. It also has a positive impact on the entrepreneurial market value. The reason for this is that government participation in industrial technology innovation mainly manifests in compensating for market failures and insufficient innovation dynamics occasioned by their specific character, rather than in an overconcern for the amount of profits on investment. However, an exceptionally large GVC, i.e. an overly large governmental share , may have a negative impact on innovation.

F. Bertoni and T. Tykvová show that GVC is not as significant a catalyst of innovation as IVC and PVC, and does not drive innovation [10]. Thus, we set forth the following hypotheses.

Hypothesis 1: Government VC promotes non-government VC investments.

Hypothesis 2: Government VC promotes innovation in invested companies.

Hypothesis 3: Government indirect venture capital (government subsidies) attracts more innovation than direct government venture capital**.**

Hypothesis 4: Government venture capital has a negative impact on return on assets

Data Analysis

Data Selection

In order to verify our hypotheses, we chose corresponding companies from Shenzhen GEM for regression analysis. Shenzhen GEM is a stock market different from the main-board market. Companies' public annual report data is available on Shenzhen GEM. Finally, for empirical analysis purposes we selected 140 companies with government venture capital and 179 companies without government venture capital listed on Shenzhen GEM in 2016–2020.

Description of the Variables

Dependent Variables

In order to explore whether government venture capital has a stimulating effect on innovation, we noted the innovative achievements of the listed companies with government venture capital.

We divided innovative achievements into two categories. The first category comprises the number of patents issued by the China National Intellectual Property Administration to listed companies each year, rather than the number of applications filed with this agency each year.

The second category includes internal research and development of publicly traded companies. According to the companies' public annual reports, internal research and development is expressed in monetary terms.

In order to link the number of issued patents and internal research and development, as well as describe all aspects of corporate innovative achievements, we have built an innovative index: 50% of issued patents and 50% of a company's internal research and development.

Apart from innovation, we also studied whether government venture capital exerts a positive impact on raising non-government venture capital.

Besides, government venture capital may also produce a certain influence on corporate operations. We have selected return on assets (ROA) as the indicator of results of business operations.

Independent Variables

When studying the role of government venture capital in financing innovation, the most important independent variable is the amount of investment in the sample of listed companies. According to the public annual report of a listed company, the share of shareholders is defined by the Statement of Joint-Stock Company. After assessing the shareholders. we obtain the number of both government and venture capital shareholders. The amount of government venture investment may be calculated by multiplying it by the authorized capital of the company (stated in the corporate balance sheet).

In the same way we may calculate the amount of investment of non-government venture capital. Non-government venture capital is the remaining venture capital that is not sourced from the government.

Besides, we also noticed the influence of interrelation between government and non-government venture capital on innovation.

Control Variables

We added control variables in order to improve our regression model.

R&D expenses play an important role in innovations, therefore we added them to the list of variables.

The share of personnel for R&D also has a notable impact on the enterprises' innovative achievements.

Government subsidies are defined by the policy pursued by the government to encourage the development of high-tech enterprises; therefore, they are also represented by a variable.

Control variables include total assets, operating income and the number of research and development personnel.

Besides, we also classify the selected sample industries into high-tech and non-high-tech categories, as presented in Table 1.

Table 1. Classification by industries

Classification of industries	Industries
High-tech	Information, biological medicine, machinery and equipment
Non-high-tech	Textile, metals, steel, food
	Real estate, transport, finance industry
	Agriculture and cattle breeding

The high-tech industry in the virtual variable equals 1, while the non-high-tech industry equals 0.
The results of variable selection are stated in Table 2.

Table 2. Variable definition

Variables	Name	Symbols	Description
Dependent	Innovative index	Index	0.5·Ln (1 + In-house R&D) + 0.5·Number of patents
	Amount of non-government venture capital	Ln (1 + NonGVC)	Natural logarithm of the amount of non-government venture capital:NonGVC = Participating interest of non-government venture institutions in capital · Equity capital
	ROA	ROA	Return on assets
Independent	Amount of government venture capital	Ln(1 + GVC)	Natural logarithm of the amount of government venture capital : GVC = Share in government venture institutions · Equity capital

Variables	Name	Symbols	Description
	Share of government venture capital	GVC%	Participation interest of non-government venture institutions in capital
	Joint influence of government venture capital and non-government venture capital	Ln (1 + GVC)· Ln(1 + NonGVC)	-
Control	Government subsidies	Ln(1 + Government subsidies)	Natural logarithm of government subsidies
	Number of research and development personnel	Number of R&D personnel	Number of research and development personnel in a company
	Total assets	Ln(1 + Total assets)	Natural logarithm of total assets
	Operating income	Ln(1 + Operating income)	Natural logarithm of operating income
	A combined effect of the share of personnel involved in R&D and investment in R&D	RD-staff ratio· Ln(1 + RDExpenditure)	–
Dummy	Industries	Dummy-industy	Dummy variables of the industry, if the industry is high-tech, the variable equals 1, otherwise it equals 0

Analysis Method

In this research we apply the multiple regression analysis method and stata statistical analysis software as an instrument for descriptive statistical analysis, correlation statistical analysis and multiple regression analysis of the basic sampled information, creation of conceptual models and verification of corresponding hypotheses.

Descriptive Statistical Analysis

Descriptive statistics is compiled on the basis of the innovative index, non-government venture capital, return on investment, government venture capital, combination of government venture capital and non-government venture capital, number and share of personnel involved in R&D, total assets, operating income, R&D expenses and of the total number of 319 companies listed in GEM in 2016-2017, as well as virtual variables. As a result of this analysis, we obtained the minimal and maximum values, mean value and standard deviation for each variable. See the results of the calculations in Table 3.

Table 3. Statistics of sample description

Indicator	N	Max	Min	Mean	Sd.
Index	1074	147.99	0	7.42	13.36
Ln(1 + NonGVC)	1074	22.59	0	5.92	8.41
ROA	1074	5.35	–116.58	–0.82	3.59
Ln(1 + GVC)	1074	21.83	0	4.86	7.99
Ln(1 + GVC)·Ln（1 + NonGVC）	1074	415.04	0	5.92	8.42
Ln(1 + Government subsidies)	1074	19.90	0	15.25	3.98
Number of R&D personnel	1074	3009	0	379.26	3.98
Ln(1 + Total assets)	1074	25.43	15.24	21.35	2.64
Ln(1 + Operating income)	1074	24.43	16.07	20.47	2.64
RD-staffratio· Ln(1 + RDExpenditure)	1074	15.45	0	3.98	2.88
Dummy-industy	1074	1	0	0.90	0.30

The above table describes the statistics for the complete sample.

Correlation Statistical Analysis

As a result of analysis, we obtained correlation ratios for each variable and ratio significance. See the results of the calculations in Table 4.

It shows that the correlation ratio between government venture capital and innovative index is positive and significant at a 1% level, i.e. there is a significant positive correlation between government venture capital and innovative index, which is a preliminary confirmation of hypothesis 2. The correlation ratio between non-government venture capital and government venture capital is positive and it is significant at a 1% level. It indicates that government and non-government venture capital correlate positively, but the issue of which of these factors influences the other needs further verification. The correlation ratio of government indirect venture capital (i.e. government subsidies) to the innovative index is also positive and is significant at a 5% level. It means that government indirect venture capital has a largely positive correlation with the innovative index. Table 4 shows that correlation ratio between corresponding variables and control variables is less than 0.8. So, it is concluded that there is no serious multiple collinearity between corresponding variables and control variables.

Table 4. Analysis of variable correlation

Variables	Index	Ln(1 + NonGVC)	ROA	Ln(1 + GVC)	Ln(1 + GVC)· ·Ln(1 + NonGVC)	Ln(1 + Government subsidies)	Number of R&D personnel	Ln(1 + Total assets)	Ln(1 + Operating income)	RD-staff ratio* Ln(1+RDExpenditure)
Index	1									
Ln(1 + NonGVC)	–0.010***	1								
ROA	0.007	0.030	1							
Ln(1 + GVC)	0.083***	0.294***	–0.05	1						
Ln(1 + GVC)·Ln(1 + NonGVC)	**–0.045**	**0.605*** **	**0.013**	**0.685*** **	**1**					
Ln(1 + Government subsidies)	0.070**	0.104***	0.007	0.056*	0.103***	1				
Number of R&D personnel	0.410***	–0.011	0.021	0.036	0.021	0.157***	1			
Ln(1 + Total assets)	0.030	0.076**	0.191***	0.090***	0.071**	0.486***	0.466***	1		
Ln(1 + Operating income)	0.022	0.073**	0.003	0.088***	0.071***	0.493***	0.420***	0.755***	1	
RD-staffratio·Ln(1 + RDExpenditure)	0.273***	–0.007	0.025	0.036	0.015	0.058*	0.492***	0.149***	0.121***	1

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

Multiple Regression Analysis

According to hypothesis 1, government venture capital has a positive impact on non-government venture capital (Table 5), therefore the regression equation is as follows:

Ln(1 + NonGVC) =
=α11 + β12Ln(1 + GVC)t + β13·Ln(1 + GVC)t – 1 + ε.

Table 5. Attractiveness of GVC for NonGVC

Ln(1 + NonGVC)	Coef.	Std.Err.	T	p
Ln(1 + GVC)t	0.213	0,56	3.78	0.000***
LLn(1 + GVC)t – 1	0.105	0.58	1.8	0.073*
Cons	4.47	0.34	13.17	0.000***

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

Table 6. Correlation between GVC and NonGVC

	Ln(1 + NonGVC)	Ln(1 + GVC)	Ln(1 + GVC)t – 1
Ln(1 + NonGVC)	1.000		
Ln(1 + GVC)	0.2970 0.000***	1.000	
Ln(1 + GVC)t – 1	0.2581 0.000***	0.7886 0.000***	1.000

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

Table 6 shows that government venture capital currently influences the attraction of non-government venture capital and is significant at a 1% level. In the previous period, government venture capital also influenced the attraction of non-government venture capital, but was significant at a 10% level.

The correlation ratio between government venture capital and non-government venture capital is currently 0.2970, while the correlation ratio with non-government venture capital in the previous period amounts to 0.2581 and their correlation ratio is significant at a 1% level.

After raising venture capital, the government sends signals to the external world demonstrating optimism and support of the project in order to attract non-government venture capital. Consequently, according to hypothesis 1, it is true that government venture capital has a positive impact on raising of non-government venture capital.

According to hypotheses 2 and 3, government venture capital has a significant influence on innovation, while indirect government venture capital (government subsidies) attracts more innovation than direct government venture capital.

Let us derive a regression equation:

Index = α21 + β22·Ln(1 + GVC) +
+ β23· Ln(1 + GVC)·Ln(1 + NonGVC)+
+ β24·Ln(1 + Government subsidies) +
+ β25·Number of R&D personnel +
+ β26·Ln(1 + Revenuefromoperation) +
+ β27·Ln(1 + Total assets) +
+ β28·(RD-staff ratio·Ln(1 + RDExpenditure)) +
+β29·dummy-industry + ε.

Table 7. Influence of government venture capital on innovation

	Index	Index
Ln(1 + GVC)	0.517*** (3.73)	
GVC%		74.048* (1.86)
Ln(1 + GVC)* Ln(1 + NonGVC)	–0.040** (–2.45)	–0.20 (–1.33)
Ln(1 + Government subsidies)	0.44* (1.82)	0.464* (1.85)
Number of R&D personnel	0.016*** (6.59)	0.017*** (6.6)
Ln(1 + Revenue from operation)	–2.70* (–1.85)	–2.528* (–1.68)
Ln(1 + Total assets)	4.09** (2.25)	4.111** (2.16)
RD-staff ratio· Ln(1 + RDExpenditure	1.14*** (2.62)7	1.206*** (2.7)
Dummy-industry	7.08** (2.36)	8.408*** (2.75)

	Index	Index
CONS	−49.72**	−54.544*
	(−1.78)	(−1.90)
F	0	0
R^2	0.4407	0.4236
Adj-R^2	0.4251	0.4071

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

As we see from Table 7, government venture capital has a significant influence on the innovative index with the ratio of 0.517. It is significant at a 1% level. It shows that government venture capital exerts a positive influence on corporate innovation, which confirms the initial hypothesis. Besides, the combined effect of government and non-government venture capital is significant at a 5% level, while the ratio equals -0.04. It means that government venture capital and non-government venture capital have a negative impact on innovation. In comparison to government venture capital, non-government venture capital attaches more importance to the earning power of enterprises than their capacity for innovation. Thus, we may also explain that the interrelation is negative.

As for hypothesis 3, although both direct government venture capital and indirect government venture capital (government subsidies) stimulate corporate innovation, Table 7 shows that the ratio of direct government venture capital equals 0.517, while the ratio of indirect government venture capital is 0.44; direct government venture capital is significant at a 1% level, and indirect government venture capital – at a 5% level. Therefore, we reject the initial hypothesis, since direct government venture capital exerts more influence on the innovative capability of enterprises than indirect government venture capital.

In addition to the above regression, we also conducted a stability test and replaced Ln (1 + GVC) with the share of shareholders in the government venture capital. It is apparent that government venture capital still promotes corporate innovation.

According to hypothesis 4, government venture capital has a negative impact on return on assets.

Let us derive the following regression equation:

$$ROA = \alpha 31 + \beta 32 \cdot Ln(1 + GVC) +$$
$$+ \beta 33 \cdot Ln(1 + GVC) \cdot Ln(1 + NonGVC) +$$
$$+ \beta 34 \cdot Ln(1 + Total\ assets) +$$
$$+ \beta 35 \cdot Ln(1 + Revenue\ from\ operation) +$$
$$+ \beta 36 \cdot Ln(1 + Government\ subsidies) +$$
$$+ \beta 37 \cdot (Number\ of\ RD\ staff) +$$
$$+ \beta 38 \cdot Ln(1 + debt) + \varepsilon.$$

Table 8. Influence of GVC on Return of Assets

ROA	Coef.	Std. Err.	T	P
Ln(1 + GVC)	−0.044	0.018	−2.49	0.013***
Ln(1 + GVC)*				
Ln(1 + NonGVC)	0.003	0.001	2.01	0.045**
Ln(1 + Total assets)	2.311	0.187	12.33	0.000***
Ln(1 + Revenue from operation)	−0.915	0.133	−6.90	0.000***
Ln(1 + Government subsidies)	0.012	0.030	0.40	0.688
Number of RD staff				
Ln(1 + debt)	−0.001	0.000	−1.43	0.154
Cons	−0.681	0.098	−6.95	0.000***
	−17.114	2.544	−6.73	0.000***

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

Government venture capital adversely affects return on assets. This result is due to the fact that government venture capital is more prone to invest in the projects that are of strategic significance for the country's macroeconomic development, are characterized by a long payback time and serious social side effects, and do not require the same return on investment as IVC and PVC. Therefore, the regression results show that the influence of GVC on return on assets is a side effect.

Conclusion

The paper studies the influence of venture companies on the direction of innovation and results of innovative activity of the Chinese government. The research produced the main empirical conclusions stated below.

First, government venture capital gives signals to the external world, influencing the number of non-government venture companies and attracting non-government venture capital. Government venture capital facilitates the attraction of more capital by enterprises, creates an investment platform and environment that play an important part in the implementation and support of IVC and PVC and is the key driver of innovation in high-tech industries.

Second, GVC significantly facilitates the promotion of companies' innovative results, which is characteristic of the current state of Chinese innovative development. The development of venture capital in China has started rather recently, and its mechanism needs improvement, since there are various problems related to implementation of venture capital in innovative projects. Therefore, the government has to play a leading role in creating a favourable environment for venture capital and provide sufficient financial support at the initial stage of venture capital development.

Third, the synergy between GVC and non-GVC has a significant negative impact on the results of innovations due to agency conflicts when government and non-government venture capital institutions have different strategic objectives of investment. This results in contradictory decisions and exerts a negative influence on the development of innovations. Besides, in accordance with China's national conditions, non-GVC prefers to invest in the enterprises at the stage of growth and maturity and in the enterprises that can generate significant profit from investment with a rather short payback time, while the GVC investment trend is more characteristic of the national development strategy. Therefore, a conflict of investment strategies between them is inevitable, and when a company utilizes both GVC and IVC or PVC, there will be a negative influence on its innovative results.

Fourth, regression analysis shows that both direct government venture capital and indirect government venture capital (government subsidies) promote innovation, but the significance of direct government venture capital is greater and the ratio is relatively larger, so direct government venture capital stimulates innovation more than indirect government venture capital.

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