



An empirical study on the innovation performance of high-tech enterprises by venture capital

Zongliang Gu

School of Economics and Management, University of Science and Technology of Jiangsu, China

1095258144@qq.com

Abstract. Whether the intervention of venture capital can promote the improvement of innovation performance of high-tech enterprises is of great significance for improving the efficiency of venture capital and promoting enterprises to choose the right type of venture capital. Using empirical analysis method, this paper first constructed a linear regression model of the impact of venture capital on the innovation performance of high-tech enterprises, utilizing the empirical analysis method. Utilizing Stata software, relevant sample data of high-tech enterprises listed on GEM was then analyzed. The results demonstrate that, thanks to venture capital, the ratio of R&D investment and the number of patent applications have been significantly increased. The result is clear: venture capital's involvement has a considerable, beneficial effect on the GEM innovation performance of high-tech businesses.

Keywords: venture capital; GEM; innovation performance

1 INTRODUCTION

In the 21st century, economic development has shifted to a new standard. With innovation as the driving force behind economic growth and the foundation for constructing a modern economic system, we must hasten the advancement of innovation-driven strategies and lead in comprehensive innovation with scientific and technological advances. The national innovation system's efficiency can be improved by fully embracing the leading and supporting role of backbone enterprises, such as high-tech enterprises, which have been identified as a major contributor to scientific and technological innovation. These enterprises, with their innovative capabilities and high added value, have become a significant source of such innovation.

In the process of development, high-tech enterprises have long R&D time, high cost and high risk.^[1] Especially in the early stage of development, bottleneck problems such as lack of capital, shortage of financing channels and immature technology will directly affect the development of enterprises. Venture capital is a form of capital matching enterprise innovation activities, which can not only ensure the continuity of capital for entrepreneurship, but also ensure the continuity of capital.^[2] There are also strong selection and supervision mechanisms, and the economic value of enterprises can be

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fairly evaluated through the market. It provides important guidance for the improvement of independent innovation ability and the promotion of overall innovation performance of high-tech enterprises.

2 LITERATURE REVIEW

Kato and Tsoka^[3] study found that venture capital has a positive effect on improving the income, profitability and return on assets of smes in a certain region. Zhang Jiawang et al., after taking listed high-tech enterprises in China as the research object, found that most of China's R&D investment has financing restrictions, which makes R&D investment relatively inefficient. Zhang Kaige and Gu Lulu discovered that, when taking listed high-tech enterprises in China as the research object, the majority of R&D investment was limited by financing restrictions, thus rendering it inefficient. They also concluded that the augmentation of capital could be a possible way for venture capital to foster enterprise innovation. Some scholars believe that the participation of venture capital institutions will send a "quality" signal and attract more funds for innovative research and development. In the aspect of improving the supervision and governance level of enterprises, venture capital has the management and decision-making power over enterprises, which enables them to intervene in the decision-making of enterprises.^[4] Chen Qi et al. Venture capital has been found to enhance the accuracy of performance forecasting by lessening the cost of agency between controlling and minority shareholders. Some literature^[5] suggests that, even after a company is listed, venture capital institutions remain motivated to take on the role of supervision and governance and manage agency risk. By changing the management compensation incentive plan, the principal-agent problem of the company is weakened, R&D personnel are encouraged, modern enterprise system is established, R&D activities are promoted, and innovation output is enhanced.^[6] Wang Hongxin et al. Venture capital institutions, occupying a large proportion of seats on the board of directors and board of supervisors of investee enterprises, have been discovered in listed manufacturing companies with venture capital participation, thus effectively controlling agent conflicts and fostering enterprise innovation.

It is found that more and more attention has been paid to the impact of venture capital on high-tech enterprises, and venture capital can effectively solve the funding gap of high-tech enterprises, share risks, and promote the improvement of innovation performance of high-tech enterprises. Constrained by the regional environment, the strength of enterprises themselves, and the pursuit of short-term interests by venture capital, the innovation performance of high-tech enterprises does not necessarily improve after obtaining venture capital and increasing innovation investment, and the empirical and quantitative research on the impact mechanism of venture capital on the innovation performance of high-tech enterprises needs to be further deepened.

3 STUDY DESIGN

3.1 Sample selection and data sources

As for the high-tech enterprises studied, the samples selected in this paper are enterprises listed on GEM from 2012 to 2020. This paper also carries out the following operations on the company samples: The samples of high-tech enterprises that do not conform to the facts, have abnormal financial status and missing key indicator data are eliminated. Finally, a total of 2563 sample data of 317 GEM high-tech enterprises were obtained.

The research data in this paper is collected manually, and the venture capital data is filtered by consulting the annual report and prospectus of listed companies. The number of patents of high-tech listed companies on GEM was obtained from the search of the State Intellectual Property Office and the company's annual report. The data of R&D expenditure, operating income, financial indicators, asset structure and other R&D investment of high-tech listed companies on GEM are derived from Wind database.

3.2 Model selection and variable selection

In order to study the sample data of GEM listed enterprises, this paper constructs an OLS econometric model. With the intervention of venture capital, the overall effect of innovation performance of high-tech enterprises listed on GEM is analyzed. This paper analyzes the effect of venture capital on innovation performance of GEM listed enterprises in general. The model establishment is as follows:

$$Innov_{it} = a_0 + \beta_1 vc_{it} + \beta_2 Control_{it} + \varepsilon_{it} (1)$$

In the above model, $Innov_{it}$ is the explained variable, which means the innovation performance level of GEM listed companies, and includes two aspects, namely, R&D expenditure and product R&D of enterprises; vc_{it} is the explanatory variable, indicating whether venture capital has entered high-tech enterprises; $Control_{it}$ is a series of control variables. ε_{it} is a random disturbance term, and β represents the coefficient. If β_1 is positive, it indicates that venture capital has a significant positive effect on the technological innovation level of GEM listed enterprises.

Innovation investment ratio (rd&ir) and patent application number (lnpat) were used as explanatory variables, and venture capital involvement (vc) was used as explanatory variables. The control variables are enterprise type (size), company size (size), age (age), asset-liability ratio (lev), cash holding ratio (cash), return on equity (roe), maximum shareholder shareholding ratio (hold), board structure (board) and proportion of independent directors (ddr). The innovation performance of high-tech enterprises is investigated in this paper, examining the overall impact of venture capital.

3.3 Descriptive statistics and correlation analysis of main variables

The descriptive statistics and correlation analysis of the main variables studied in this paper are shown in Table 1 and Table 2. The mean rd&ir of R&D was 7.164, the

maximum was 98.39, and the standard deviation was 6.466. It can be seen that there is a huge difference between the R&D investment ratios of different high-tech enterprises. The mean of patent applications (lnpat) is 1.790, the maximum is 6.458, and the standard deviation is 1.488. It can be seen that the standard deviation is small, indicating that although the number of patent applications of different high-tech enterprises is different, and even the number of patent applications of some enterprises is 0, it is generally more stable than this variable compared with R&D investment.

In terms of explanatory variables, the mean value and standard deviation of VC were 0.371 and 0.483. It shows that about 37.1% of the selected study samples have venture capital participation.

Table 1. Descriptive statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
rd&ir	2,563	7.164	6.466	0	98.39
lnpat	2,563	1.790	1.488	0	6.458
vc	2,563	0.371	0.483	0	1

Table 2. Correlation analysis

	rd&ir	lnpat	vc
rd&ir	1		
lnpat	0.042**	1	
vc	0.065***	0.076***	1

4 EMPIRICAL ANALYSIS

4.1 The performance of high-tech enterprises in terms of innovation was determined by regression of venture capital results.

The empirical analysis results of the effect of venture capital on the innovation performance of high-tech enterprises are presented in the Table 3.

Table 3. The regression results of venture capital on the innovation performance of high-tech enterprises

VARIABLES	(1) rd&ir	(2) lnpat
vc	0.912*** (3.43)	0.252*** (4.22)

The coefficient of venture capital involvement (vc) for the innovation input ratio (rd&ir) is 0.912 and is statistically significant at the 1% level. For the logarithm of patent applications (lnpat) variable, the coefficient of venture capital involvement (vc) is 0.252, also significant at the 1% level. This shows that with the help of venture capital, the innovation input and patent application of enterprises have been significantly

promoted. Therefore, it is concluded that venture capital has a significant value-added effect on the innovation performance of high-tech enterprises on GEM.

4.2 Robustness test

In this paper, the replacement variable method is used to test the robustness. The specific replacement method is: replace the logarithm of the number of patent applications (Inpat) of the explained variable with the number of patent grants (inv). Compare whether the results before and after are consistent. The robustness test results of venture capital on innovation performance of high-tech enterprises are displayed in the Table 4.

Table 4. Robustness test results

VARIABLES	(1) rd&ir	(2) inv
vc	0.912*** (3.43)	9.553*** (4.86)

The regression coefficients of venture capital are 0.912 and 9.553 respectively, both of which are significant at a 1% level. This is in agreement with prior studies, suggesting that the regression results are reliable.

5 MANAGEMENT STRATEGIES AND RECOMMENDATIONS

Based on the conclusions of the previous research, this chapter puts forward corresponding management strategies and suggestions for both parties from the perspective of high-tech enterprises and venture capital institutions.

For venture capital institutions, because capital provision is the most important feature of venture capital, venture capital institutions should put capital provision in the first place when investing in high-tech enterprises, and at the same time occupy the largest proportion. The effect of venture capital funding on the R&D stage of enterprises is very obvious, so venture capital institutions should focus on the investment ratio of R&D funds when investing. When venture capital is carrying out the supervision and management of talents in the field of enterprise supervision, it should appropriately give full play to the supervision and governance mechanism of venture capital institutions, introduce an appropriate number and high quality management talents, and avoid the negative impact caused by the decline of innovation performance. At the same time, part of the funds for the introduction of management personnel can be used to improve the original management structure of the enterprise. The social resources brought by venture capital institutions have a certain utilization value, but it is necessary to build a valuable relationship network as much as possible and avoid unnecessary consumption in the relationship network, so as to maintain the relationship between the

enterprise and many interest groups, so as to promote the improvement of innovation performance.

For high-tech enterprises, because the impact of venture capital on the R&D stage is obvious, high-tech enterprises should pay attention to the investment of R&D funds, cultivate the level and quality of technical R&D personnel, and adopt more advanced production machinery and equipment. At the same time, when improving R&D investment, we should not only pay attention to the degree of investment, but also pay attention to the quality of investment, avoid meaningless consumption, and achieve value for "investment". Specific behaviors can be manifested in: the establishment of R&D centers, strengthening cooperation with universities, understanding the market orientation and corresponding policies, and being able to respond in a timely manner.

6 CONCLUSION

This paper examines the impact of venture capital on the innovation performance of high-tech enterprises, using the panel data of 317 listed on GEM from 2012 to 2020 as its sample. Its conclusions are that venture capital's involvement has a noteworthy value-added effect on the innovation performance of these enterprises. Entering venture capital has seen a marked rise in the proportion of R&D investment and the amount of patent applications for businesses.

In this paper, enterprises on GEM are selected in the study of the characteristics of venture capital, and listed companies in other sectors can be taken into consideration in the future. As for the selection of characteristic variables, the characteristics of venture capital are also constantly updated with the progress of The Times. With the renewal of venture capital institutions, it is believed that the research results on the characteristics of venture capital will become more and more abundant.

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