

Venture Capital and Technological Innovation in High-Tech Enterprises: Data from Listed Companies on the Growth Enterprise Market

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Abstract. The emergence of venture capital is the improvement of domestic and foreign capital markets, which is conducive to the survival and development of high-tech enterprises and economic growth. However, whether the participation of venture capital institutions can promote the technological innovation of high-tech enterprises has not been conclusive. According to the CV Source Investment Database, internet and information technology companies in the high-tech industry have been more favored by venture capital institutions in recent years. This article takes 133 companies listed on the GEM in 2016-2017 as an example, using empirical methods to analyze the impact of venture capital institutions on the technological innovation behavior of high-tech enterprises. The results show that 86% of high-tech enterprises will have risk capital injection in the IPO stage in recent years, and there is a positive relationship between the proportion of venture capital holdings and the technological innovation of high-tech enterprises.

Introduction

Technological innovation behavior of enterprises can bring more high-quality and efficient products and services to the society, plays a vital role in the national innovation system, our government departments attach great importance to and strongly support the technological innovation behavior of enterprises, and have introduced a series of related policies to improve China's capital market and fair and open competitive environment.

Venture capital is mainly the financing method of the main investor to provide funds to the start-up and obtain the equity of the company, it's an equity investment behavior, focusing on innovative projects and start-up enterprises. It would obtain high profits by helping enterprises to go public or be acquired. At present, China's venture capital industry has shown a steady expansion trend in the number of institutions, total capital, investment income and other aspects. According to the CVSource Investment Database, China's venture capital is concentrated in information transmission, software, information technology services and manufacturing industries, investment focus further shifted from traditional manufacturing to computer, software development, communications, pharmaceutical and chemical industry etc. These industries are technology-intensive industries, products are not easy to imitate, high value-added, better market prospects and so on.

Based on the research of Chen Jianli (2011) and Shen Liping (2015), this paper further analyzes whether the entry of venture capital institutions has a positive impact on the output of innovation results of high-tech enterprises in recent years.

Literature Review and Research Hypothesis

In the study of the relationship between venture capital and enterprise technological innovation, most scholars think that venture capital can promote the innovative behavior of enterprises, and some scholars think that venture capital has no effect on the innovation behavior of enterprises or has some negative impact.

Researches on the impact of venture capital on enterprise innovation have been carried out earlier abroad. Kortum and Lerner (2000) found that venture capital has more positive effect on

technological innovation than R&D investment through empirical analysis of 20 industries. Engel and Keilbach (2007) took German enterprise panel data as an example, they analyzed the influence of venture capital on the number of patent applications and the growth rate of firms by using the propensity score matching method, and found that venture capital can promote the growth rate of firms, but can't promote the increase of firms' patent applications, and venture capital plays an important role in the commercialization of firms' innovation performance. Pradhan et al. (2017) confirmed the one-way or two-way influence relationship between venture capital and technological innovation in 19 European countries, and proposed that attention should be paid to the differences between venture capital and technological innovation in different countries.

Chen Gongmeng (2009) believed that both micro-level innovation technology transformation and macro-level economic intensive growth need to rely on venture capital, venture capital participation can not only improve the innovation environment, but also improve innovation efficiency. Chen Jianli (2011) empirically examined the relationship between venture capital and technological innovation by taking high-tech enterprises in GEM as a sample, and found that venture capital participation does not bring more technological innovation resources to high-tech enterprises, nor can it promote high-tech enterprises to create more technological innovation results and benefits. Wang Qi (2016) theoretically analyzed the impact of venture capital enterprises' technological innovation, and empirically proved that it has a promoting effect on venture capital activities and quantity, and venture capital institutions have a greater promoting effect on enterprise technological innovation by increasing investment in the development period of enterprises.

When investors look for and identify start-ups, they often face information asymmetry, especially when the technological innovation of enterprises becomes a commodity, the problem of information asymmetry will be more obvious. Because innovation is a trade secret, companies usually do not disclose it to the outside world. On the other hand, many investors cannot identify and evaluate the future value of innovation because the industry information involved in innovation is relatively cutting-edge. As a new type of investment and finance, With sufficient funds, but also with expertise and skills in relevant fields, the ability to identify the value of an enterprise 's innovation activities is stronger, and based on the principal-agent relationship between venture capital institutions and managers of high-tech enterprises, Venture capital institutions will set up some incentive mechanisms to enhance the efforts of entrepreneurs and thus enhance the value of enterprises, and the technological innovation achievements of high-tech enterprises (including patent applications, software copyright, etc.) and R&D investment can largely reflect their value.

In summary, this paper represents the level of technological innovation of high-tech enterprises by the number of enterprise patent applications and the ratio of research and development investment, so the following assumptions are put forward:

Hypothesis 1: There are more patent applications for high-tech enterprises with venture capital participation;

Hypothesis 2: Higher proportion of research and development investment in high-tech enterprises with venture capital participation;

Hypothesis 3: The proportion of venture capital holdings is positively correlated with the number of patent applications filed by high-tech enterprises;

Hypothesis 4: The proportion of venture capital holdings is positively correlated with the proportion of investment in research and development by high-tech enterprises.

Research Design

Definition and Measurement of key Variables

Dependent Variables.

The level of technological innovation is difficult to observe directly, and the patent filed by enterprises (PATENT) has the characteristics of observable, difficult to imitate, and costly, it's a good indicator of the level of measurement technology innovation. Considering that patent output takes a certain time span, this paper measures the level of technology innovation in the total number of patent

applications filed by high-tech enterprises in the year of GEM listing and the following two years, and the data is manually collected in the CSMAR database and the National Intellectual Property Office. R&D investment is the support given by an enterprise to technological innovation, is the key factor that affects the technological innovation achievement of enterprises, and the ratio of R & D investment to operating income (RD) can also reflect the technological innovation level of enterprises to a certain extent. The RD investment level of enterprises is expressed by the average R & D investment ratio of the year of listing and the second year, and the data is from the CSMAR database.

Independent Variable.

If there is a venture capital institution involved (VC), from the list of the top ten shareholders of the company to determine whether there are venture capital institutions, if there're venture capital institutions record 1, no venture capital institutions record 0 and meet one of the following two conditions can see it as Venture capital institution: The company name includes words such as "start-up investment", "innovation investment" or "risk investment"(Cheng Liwei et al., 2019); the related website introduces its main business or its "historical investment" in its historical business. Companies that act as venture capital institutions such as "innovation investments".

The number of venture capital institutions (NUMVC), determines the number of venture capital institutions among shareholders from the list of the top ten shareholders announced in the year of the listing of the enterprise.

The proportion of venture capital holdings (VCSHARE) can be represented by the sum of the shareholdings of venture capital institutions among the top ten shareholders of an enterprise in the year of listing on the Growth Enterprise Market.

Control Variables.

Enterprise size (SIZE), as the larger enterprises have more human and material resources, which affect the R&D ability and innovation level of enterprises, it is expressed by the natural logarithm of the total assets of enterprises at the time of listing.

The age of the enterprise (AGE) is expressed by the company minus the year of its establishment in the year of listing on the GEM.

Model Construction

In order to measure the impact of venture capital and its shareholding ratio on the number of patent applications, the multivariate linear regression model 1 was established.

$$\text{Model 1: PATENT} = a + b\text{SIZE} + c\text{AGE} + d\text{VC} + e\text{NUMVC} + f\text{VCSHARE} + g \quad (1)$$

In order to measure the impact of venture capital and its shareholding ratio on R&D investment, the multivariate linear regression model 2 was established.

$$\text{Model 2: RD} = a + b\text{SIZE} + c\text{AGE} + d\text{VC} + e\text{NUMVC} + f\text{VCSHARE} + g \quad (2)$$

Empirical Analysis

Descriptive Statistics

From the descriptive statistical analysis data of the variables listed in Table 1, it can be seen that the assets scale of the high-tech enterprises designed in this study ranges from 45 million yuan to 599 million yuan, the time range from establishment to listing is from 6 to 32 years, and the asset scale and the age span of the enterprises are relatively large, which indicates that the data of this study design is quite extensive and the research results are representative, the proportion of venture capital institutions, the ratio of R&D investment and the standard deviation of patents. Both are close to or greater than the mean, again indicating that this data has a certain degree of credibility and

persuasiveness.

It also can be seen that in the presence of venture capital institutions (VC) dummy variables, 86% of the high-tech enterprises in the sample have venture capital institutions in the year of IPO, and the average number of venture capital institutions among the top 10 shareholders is 2.06, indicating that the high-tech enterprises in the sample have 2 venture capital institutions among the top 10 shareholders on average at the time of IPO. The activity of venture capital investment in high-tech enterprises has been relatively high in recent years.

Table 1.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Standard deviation
SIZE	133	0.45	5.99	1.77	0.97
AGE	133	6	32	14.25	4.64
VC	133	0	1	0.86	0.35
NUMVC	133	0	6	2.06	1.43
VCSHARE	133	0.00	0.65	0.12	0.13
RD	133	0.02	0.39	0.08	0.07
PATENT	133	1	337	56	63.39
Effective N	133				

Correlation Analysis

In order to detect whether the correlation between variables is significant, the SPSS software is used to analyze the correlation data. Through the data analysis results, it can be seen that there is significant correlation among multiple variables. Among them, the negative correlation between enterprise age and R&D investment is significant. The number of venture capital institutions existing in enterprise shareholders is significantly positively correlated with patent output. The shareholding ratio of venture capital institutions and patent output also show a significant positive correlation. Further analysis of the paper laid the foundation.

Table 2.

Correlation Analysis							
	SIZE	AGE	VC	NUMVC	VCSHARE	RD	PATENT
SIZE	1	0.196 *	0.046	0.037	0.017	0.041	0.170
		0.024	0.596	0.676	0.844	0.637	0.051
AGE	0.196 *	1	-0.136	-0.210 *	-0.229 **	-0.284 **	-0.169
	0.024		0.118	0.015	0.008	0.001	0.052
VC	0.046	-0.136	1	0.589 **	0.376 **	0.036	0.168
	0.596	0.118		0.000	0.000	0.679	0.053
NUMVC	0.037	-0.210 *	0.589 **	1	0.691 **	0.051	0.320 **
	0.676	0.015	0.000		0.000	0.559	0.000
VCSHARE	0.017	-0.229 **	0.376 **	0.691 **	1	0.159	0.401 **
	0.844	0.008	0.000	0.000		0.067	0.000
RD	0.041	-0.284 **	0.036	0.051	0.159	1	0.195 *
	0.637	0.001	0.679	0.559	0.067		0.024
PATENT	0.17	-0.169	0.168	0.320 **	0.401 **	0.195 *	1
	0.051	0.052	0.053	0.000	0.000	0.024	
N	133	133	133	133	133	133	133

*, ** indicate significant correlation at the 0.05 and 0.01 levels (both sides), respectively.

Regression Analysis

Through the regression results of the model 1, it can be seen that the regression results of the number of patent applications between high-tech enterprises and enterprises involved in venture capital institutions are not significant, so reject the hypothesis 1, and the participation of venture capital institutions does not significantly promote the output of high-tech enterprises. The positive return of the risk investment shareholding ratio of the enterprise in the year of listing and the number of patents is significant. The hypothesis 3 is accepted, that indicates the high-tech enterprises listed in the recent years have higher proportion of venture capital. The innovation of the company's innovation is even more remarkable.

Through the model 2 regression results, the number and proportion of venture capital institutions have no significant influence on the level of R&D investment, therefore, we reject hypothesis 2 and hypothesis 4, but the regression results show that the establishment years of high-tech enterprises negatively affect their R&D level, indicating that as the enterprise matures and the operating income increases, the proportion of R&D investment will gradually decrease.

Table 3.

Model Regression Results		
	Model 1 (PATENT)	Model 2 (RD)
SIZE	0.186*	0.091
	(0.015)	(0.242)
AGE	-0.117	-0.284**
	(0.162)	(0.003)
VC	-0.025	0.009
	(0.799)	(0.931)
NUMVC	0.078	-0.152
	(0.535)	(0.252)
VCSHARE	0.326***	0.192
	(0.000)	(0.102)

*, **, *** indicate significant correlation at the 0.05, 0.01, 0.001 levels (both sides), respectively.

Conclusions and Recommendations

Taking the 133 enterprises listed on the GEM in 2016-2017 as an example, selecting data from the CSMAR database, Shenzhen Stock Exchange website and Giant Tide Information Network empirically analyze the impact of venture capital on technological innovation of high-tech enterprises, and obtain the following research conclusions.

The participation of risk-free investment and the number of venture capital institutions have no significant impact on the number of patent applications filed by enterprises. However, if a venture capital institution occupies a certain shareholding ratio, it will promote the patent application of enterprises, indicating that only high-tech enterprises have a large correlation with the interests of venture capital institutions, the participation of venture capital can promote the patent application of high-tech enterprises. The level of technological innovation reflects its current research and development capabilities as well as its future development potential and value. Therefore, due to the nature of risk capital chasing interests, when the proportion of high-tech enterprises holding shares is large, it will significantly accelerate its technological innovation achievements.

Whether high-tech enterprises have the participation of venture capital institutions, the number of venture capital institutions, and the proportion of venture capital shares have no significant impact on the proportion of R&D investment of high-tech enterprises, indicating that the proportion of R&D investment of enterprises is less affected by venture capital. This is because most venture capital still has short-sightedness for the invested companies. Increasing R&D investment will directly affect the current income of venture capital institutions. Therefore, it is not willing for them to increase the future value of the company at the expense of its current earnings, but they will help high-tech improve the overall level of the company in terms of talent introduction and business management.

The technological innovation activities of high-tech enterprises affect the overall technological level of the society and the development and progress of the country, government should continue to support the development of high-tech enterprises in the start-up or growth period. In view of the dependence of high-tech enterprises in the growth and development period on external resources, the government should guide venture capital into high-tech enterprises to alleviate their demand for capital to a certain extent. In addition, relevant incentive policies should be formulated to support venture capital institutions to increase their shareholding in the invested high-tech enterprises and increase the interest relationship between venture capital and high-tech enterprises in order to enhance the development assistance of venture capital institutions.

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