THE IMPACT OF VENTURE CAPITAL INSTITUTIONS ON THE INNOVATION OF SCIENCE AND TECHNOLOGY INNOVATION BOARD ENTERPRISES

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ABSTRACT

As an essential accelerator of supply-side structural reform and technological innovation, venture capital (VC for short) plays an increasingly prominent role in the capital market. When venture capital alleviates the complex and expensive financing problems of small and medium-sized enterprises, it can improve the innovation ability of enterprises by improving the internal governance of small and medium-sized enterprises, increasing stock liquidity, and enhancing financing capabilities. However, the existing studies have different views on the "certification supervision function" and "name-by-name hypothesis function" of venture capital. Therefore, whether venture capital can impact corporate innovation and how to create value for listed companies is of great importance and worth further research. Based on the information asymmetry theory, certification supervision theory, name-by-name hypothesis theory and value-added service theory, this paper studies the relationship between venture capital heterogeneity and innovation of listed companies on the Science and Technology Innovation Board and constructs the relationship between venture capital heterogeneity and corporate value path. Based on the theoretical analysis framework, it analyzes the channels through which venture capital heterogeneity affects corporate innovation to provide valuable references for the behavioral decisions of government departments, venture capital institutions and listed companies.

This paper selects the research objects of listed companies on the Science and Technology Innovation Board based on theoretical analysis. It uses its 2019-2021 data for empirical testing to draw the following conclusions: venture capital can play a certain degree of certification supervision and value-added service functions. The involvement of venture capital can promote corporate innovation. In terms of the heterogeneity of venture

capital, the number of venture capital, the shareholding ratio of venture capital and the background of venture capital can improve the innovation ability of enterprises, and the performance is different in different industries.

The research conclusions of this paper supplement the research literature on the impact of venture capital on the innovation of listed companies on the Science and Technology Innovation Board to a certain extent: it has specific guiding significance for the scientific selection of professional venture capital institutions for listed companies on the Science and Technology Innovation Board. To better play the value-added effect of venture capital on the innovation ability of listed companies. The research conclusions of this paper have particular and guiding significance for venture capital institutions in the market to choose high-quality listed companies so that they can better provide value-added services for listed companies. It is also conducive to the government's introduction of policies related to the operation of venture capital, strengthening the guidance and supervision of venture capital, and achieving a reasonable allocation of social resources.

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CHAPTER 1

INTRODUCTION

Research Motivation

Innovation is an important driving force for the long-term and stable growth of the national economy. Since the opening of the Science and Technology Innovation Board, China has encouraged many innovative companies to list on the Science and Technology Innovation Board. The relevant companies on the Science and Technology Innovation Board reflect the overall strength of technology in various industries in China. However, for small-scale entrepreneurial enterprises needing more funds, innovation is a production activity with a long cycle, significant investment, and severe high-tech risks. Few start-ups have the financial firepower to invest in research and development to innovate a global number one product, especially in biomedicine. However, with the opening of the science and technology innovation board, many venture capitals have poured into the high-tech industry due to better exit channels for funds. As a financial innovation primarily invested in start-up companies, venture capital can alleviate the financing difficulties for high-risk and high-investment high-tech start-ups and provide them with value-added services in management improvement and resource integration. It can primarily empower start-ups, and venture capitals are also a perfect fit for innovative high-tech companies. Throughout the development history of high-tech industries at domestic and abroad, using venture capital to integrate technology and capital is a shortcut to promote technological innovation and realize the rapid development of high-tech enterprises. However, due to the intervention of venture capital institutions, the high-tech industry is prone to bubbles, and it is straightforward to withstand the cycle from the industry's peak to the trough.

In upstream of the industry, some related companies even completed 2-3 rounds of financing in a year, which significantly increased the overall valuation of the industry, and the entire industry became a bubble. In the downturn of the industry, there will be quality companies that are seriously undervalued, and they may go bankrupt due to lack of cash flow. Therefore, the intervention of capital is a double-edged sword for the industry. It can both bring in a large amount of capital to finance corporate research and development. But at the same time, it may also lead to a mixed industry, the bubble burst, making the industry into a trough. Capital drives the industry bubble and injects vitality into the industry.

This article explores how much impact venture capital institutions can have on the innovation of enterprises on the Science and Technology Innovation Board through research. Whether the involvement of venture capital institutions can promote enterprise innovation; whether the number of venture capital institutions entering will have a differential impact on enterprise innovation; and whether the shareholding ratio of venture capital will affect enterprise innovation; for enterprise innovation, if the start-up team holds a small proportion of shares, will it inhibit the company from conducting innovative research and development; for enterprise innovation, venture capital institutions with a state-owned background will promote enterprises to carry out innovative research and development. Based on the above four perspectives, this paper will use the entire China Science and Technology Innovation Board as a data set and use theoretical and empirical analysis to explore the impact of venture capital institutions on corporate innovation.

Research Question

In the TMT era, policies were further liberalized to encourage the entry of foreign funds, and a large number of US dollars entered China. Many local governments have also

become the main force of fund investment. China's venture capital fund model has begun to be recognized by the market and tends to be formalized, and the venture capital model has begun to prevail. At the same time, many funds have also gained a lot with the rise of several Internet giants. The existing top funds, such as Sequoia Capital, Hillhouse Capital, Wuyuan Capital, and Dachen Capital, are all giants achieved in the Internet age. In the Internet age, a company only needs 4-5 years of growth to become a billionaire. It is unmatched and surpassed in any industry and era. Short-term money is pouring into the venture capital industry.

However, with the gradual saturation of the Internet industry, the weakening of the ability of the real estate to drive the economy, and external crises such as the Sino-US trade war and anti-globalization, China's model of relying on the Internet and real estate to drive the economy has become unsustainable. The future will be dominated by complex technology. Only by developing high-tech industries such as semiconductors, new energy, and medicine and solving agricultural and industry bottlenecks can China achieve structural transformation, increase domestic demand, and maintain healthy and stable economic development. Therefore, venture capital funds will have a more prominent position in the development of the whole society. However, due to China's immature venture capital model, most existing leading funds were born in the Internet era and pursued short-term benefits. At the same time, the complicated technology industry has complex technology, a long cycle, and slow realization, and it is difficult for the listed market value to reach 100 billion. These industry characteristics will challenge these funds that pursue fast realization and test whether China's venture capital model can support the development of China's complex technology companies. Therefore, based on the above

doubts, this paper takes the innovative enterprises on the Science and Technology Innovation Board as the research object and will start from four perspectives to study how much impact venture capital can have on corporate innovation. At the same time, we refine our questions to explore whether the shareholding ratio of venture capital institutions will have a greater impact on corporate innovation, whether the number of venture capital institutions entering the company can help enterprises to innovate, and whether the background of venture capital institutions will have an impact on corporate innovation. It is intended to provide some theoretical suggestions for China's follow-up venture capital model to support the development of complex technology companies by studying the development trajectory of complicated technology companies in the past. It can provide some theoretical suggestions for Chinese venture capital to support the subsequent development of science and technology enterprises and provide some theoretical basis for the rise of China's science and technology era.

The innovation of this article is that the data we selected are all from the companies on the Science and Technology Innovation Board. The Science and Technology Innovation Board is a newly established listing channel in China in 2018. The main purpose is to encourage large-scale technology-based companies with scientific and technological attributes but no income to go public. This path also provides a suitable launch path for venture capital institutions. The companies listed on the Science and Technology Innovation Board can represent the overall level of science and technology innovation enterprises in China to a certain extent. Based on the opening of the Science and Technology Innovation Board, China's venture capital institutions have officially begun to explore the hard technology industry. Based on this research, we can more clearly see the

overall development of China's science and technology enterprises and the overall development of the Venture Capital, and study what types of Venture Capital institutions are currently more active in the market; and whether the venture capital model can significantly promote the development of China's hard technology enterprises.

CHAPTER 2

LITERATURE REVIEW & THEORY

Literature Review

Review of Domestic Literature

Regarding how venture capital funds affect corporate Innovation, most domestic scholars have demonstrated that venture capital funds have a relatively positive impact on corporate Innovation from different perspectives. Fang Min (2022) believes that due to the good fit between venture capital and entrepreneurial technology companies, venture capital has the characteristics of high-risk and high-return investment, and the investment cycle is generally long and requires advanced professional management experience. While enterprises innovation also takes a long time. Once successful, it can yield huge benefits. Therefore, venture capital is the best financing method for entrepreneurial enterprises to carry out technological innovation and increase the core competitiveness of enterprises. Enhancing enterprises' scientific and technological strength through venture capital has become a major issue that every enterprise manager and researcher needs to face. Therefore, under the background of the vigorous development of the GEM, from the perspective of listed companies, venture capital's impact on enterprises' technological Innovation is analyzed from three aspects: input, benefit, and output of technological Innovation. Moreover, it is found that compared with enterprises without venture capital background, enterprises with venture capital background have a higher proportion of R&D investment. The length of venture capital investment has a weak positive correlation with enterprise R&D investment, and it is related to technological innovation benefits and technology Innovation output has a significant negative correlation. Li Xiwen (2022) believes that no

matter at the industry level or the company level, most empirical research supports venture capitals to promote innovation activities. From the analysis of the whole process before and after investment, in the pre-investment screening stage, the diversification of the venture capital portfolio and the quality of resource delivery have an inverted U-shaped relationship, which indirectly affects corporate Innovation. This indicates that venture capital institutions positively adjust post-investment management and promote enterprise innovation through screening of enterprise resource conversion ability. In the investment stage, the investment itself endorses the enterprise, releases positive signals to relevant audiences, and improves the innovation efficiency of the enterprise. In the post-investment management stage, venture capital directly transfers industry resources and contacts to the enterprise to increase innovation output, to provide strategic guidance for the invested companies, optimize and improve the utilization rate of innovation resources. The author takes the companies listed on the GEM from 2009 to 2020 as samples and uses multiple linear regression to test the impact of venture capital background heterogeneity on corporate innovation capabilities. The results show that a venture capital background significantly affects corporate innovation capabilities. First, compared with a government background, venture capital with non-government background has a more significant incentive effect on enterprise innovation; second, the richer the experience of venture capital, the more significant the impact on enterprise R&D investment, but the impact on the number and quality of patents is negative. Based on this, the following conclusions are drawn: the innovation efficiency of government-backed venture capital needs to be strengthened, and it is necessary to continue to delegate power to the market. The evaluation index of high-tech enterprises can be properly introduced into the R&D

achievement index to guide venture capital to focus on improving the transformation of innovation achievements. Jin Hui (2022) put forward the concept of "risk tolerance," which is interpreted as the tolerance of venture capital institutions to fail. The author pointed out that venture capital failure tolerance plays an important role in stimulating the technological Innovation of enterprises. Based on constructing the failure tolerance index adapted to China's venture capital investment, the article takes China's Shanghai and Shenzhen A-share listed companies from 1999 to 2020 as a research sample and analyzes the impact of venture capital failure tolerance on corporate technological Innovation through a two-way fixed effect model, and Further analysis of the influence differences brought about by choice of venture capital stage. The research conclusion is that the failure tolerance of venture capital has a continuous and significant positive impact on enterprise technological innovation. The earlier the venture capital enters the stage of the funded enterprise, the more significant the positive impact of failure tolerance on enterprise technological innovation. It also shows that government funds should support industrial development and encourage venture capital to establish a fault-tolerant mechanism to provide continuous Innovation for China's economic development. Based on the above analysis, this paper puts forward the first hypothesis: venture capital can significantly promote enterprise innovation.

Many domestic scholars have used GEM enterprises as the data set to carry out empirical regression regarding the impact of venture capital shareholding ratio on enterprises. The research found that the venture capital shareholding ratio can significantly promote enterprise innovation, and the shareholding ratio of venture capital has a greater impact on enterprise innovation. At the same time, the intervention of venture capital has

a favorable impact on its equity structure and corporate governance. For example, Shi Lin (2021) analyzed the impact of equity settings on corporate Innovation, using the annual data of ChiNext-listed companies from 2010 to 2019 as a sample and strictly processed the relevant data using descriptive statistics and regression analysis. It is believed that the increase of equity concentration will have an inhibitory effect on corporate innovation investment; the increase in equity balance and executive shareholding ratio will effectively promote corporate innovation investment; from the perspective of the nature of shareholders, venture capital shareholding ratio, institutional investors The increase in the shareholding ratio will promote corporate innovation investment to varying degrees: among them, the shareholding ratio of venture capital has the most significant effect on promoting corporate innovation investment, followed by the shareholding ratio of institutional investors; The effect of innovation investment is not significant, which may be related to the small number of enterprises with state-owned shares in the GEM market; while the proportion of foreign capital shares is conducive to the development of enterprises' internationalization strategy, but it will have an inhibitory effect on enterprise innovation investment. Wang Xiao (2021) used A-share-listed biopharmaceutical companies as samples for empirical analysis from 2000 to 2020 and found that venture capital will positively impact biopharmaceutical companies' value. The higher the shareholding ratio, the longer the investment period and the joint investment. The higher the number, the stronger the promotion effect on corporate value; secondly, compared with the investment period and the number of joint investments, the shareholding ratio has the greatest contribution to the value of biopharmaceutical companies, that is, the shareholding ratio is the cause of different risk investments on biopharmaceuticals. The most important

factors are affecting different degrees of pharmaceutical enterprise value. Wang Lili (2021) took the 2016-2019 GEM companies as the research object and conducted an empirical analysis of the impact of private equity investment on corporate innovation capabilities. The research found that companies with private equity investment have stronger innovation capabilities. Further analysis found that private equity investment. The shareholding ratio of investment and joint investment has a positive effect on the innovation ability of enterprises. That is, as the shareholding ratio of private equity investment increases, the innovation ability of enterprises will also increase; the more joint investment of private equity investment institutions, the stronger the innovation ability of enterprises, which expands the research on private equity investment and corporate innovation capabilities. It also provides a certain reference for companies to improve their innovation capabilities. Liu Eping (2022) conducted an empirical study on the data of China's A-share listed companies from 2007 to 2018 and used the "scenario conversion regression" method to test the robustness of the hypothesis proposed in this paper. The research shows that venture capital can promote corporate risk-taking; a high shareholding ratio, joint investment, and high-reputation venture capital have more obvious incentives for corporate risk-taking. Further research found that improving corporate governance capabilities and reducing corporate financing constraints are important channels through which venture capital affects corporate risk-taking. Improving corporate risk-taking level will stimulate corporate R&D and technology mergers and acquisitions, and corporate risk-taking plays an intermediary role between venture capital and corporate innovation investment decisions. He Tianyang (2022) took the family enterprises listed on China's GEM from 2011 to 2020 as the analysis target, and constructed the comprehensive index G of family enterprise

growth through principal component analysis, starting from the characteristics of venture capital (whether there is venture capital, whether joint venture investment and venture capital holdings), established a model and used appropriate measurements to empirically test and analyze the impact of venture capital and family business growth and its internal mechanism. It was found that venture capital participation improved the growth of family businesses, and those with venture capital backgrounds Family businesses are better able to grow. The participation of venture capital impacts the corporate governance of family enterprises. Family enterprises with venture capital backgrounds have larger board sizes and proportions of independent directors, higher management incentive levels, and lower equity concentration. In the process of venture capital affecting the growth of the family business, the size of the board of directors, the proportion of independent directors, and management incentives play a part of the intermediary role. At the same time, the concentration of ownership does not have an intermediary role. In addition, the research on the characteristic variables of venture capital shows that the shareholding ratio of venture capital has a positive relationship with the growth of a family business. The higher the shareholding ratio of venture capital, the better the growth of the family business; The growth has no significant impact. Although the joint investment has expanded the financing boundary of the enterprise, it has not yet played a positive role in the growth of the family business. Li Haiting (2022) selected 215 companies listed on the Science and Technology Innovation Board as of the research day as research samples and used descriptive data and OLS regression methods to explore the impact of private equity financing on the innovation performance of Science and Technology Innovation Board companies. The results show that the addition of private equity investment can help improve the Innovation and

development performance of the invested enterprises; the higher the proportion of private equity holdings, the better the promotion effect; investment institutions with foreign capital participation can promote innovation efficiency. Based on this, this paper puts forward the second hypothesis: the higher the proportion of venture capital holdings, the stronger the innovation ability of enterprises.

Regarding the research on the impact of the number of investment institutions on enterprise innovation, some scholars also pointed out that the number and the degree of specialization will significantly affect enterprise innovation. Investment institutions are mainly divided into socialized funds, government guidance funds, and industrial funds; socialized funds are relatively more professional and pursue more significant benefits, while state-owned funds are primarily to attract investment and have no impact on innovation capabilities. The requirements are low, and the industrial capital is more to supplement the business circle of the parent company. Therefore, many scholars have also suggested that if the company invests more in socialization funds, it will be more conducive to stimulating corporate Innovation. The ability of state-owned enterprises and industrial funds to influence corporate Innovation could be more vital. Duan Li (2022) took 148 companies listed on the Science and Technology Innovation Board as a research sample and established an econometric model for empirical verification. The research results found that: first, the higher the professional level of the lead investor, the stronger the ability to eliminate information asymmetry between VC (venture capital) and the invested company, the ability to select investment partners, and the ability to provide professional value-added services to the company, the effect of improving the innovation performance of science and technology innovation enterprises is more significant; second, government guidance

funds increase transaction costs due to risk aversion and cause conflicts of interest with enterprises and VCs, making them more effective in promoting science and technology innovation compared with private capital VCs. The effect of corporate innovation performance is weak; third, the more even the investment share in the joint investment is, the more likely it is to eliminate the uneven share distribution. When the VC with a small share appears as a "free ride" phenomenon, the effect of promoting the innovation performance of science and technology innovation enterprises is more significant. Luo Chaoliang (2022) took the 2016-2020 joint investment events in China's cultural tourism entrepreneurial sector as a sample and used the exponential random graph model to test the "leader-follower" relationship mechanism empirically. The results showed factors such as the convergence of capital sources and complementary investment experience. It is an essential basis for the "leader-follower" relationship and presents a network structure characteristic of popularity and transitive closedness.

Zhang Fang (2020) took the companies listed on the GEM from 2016 to 2018 as the research object and analyzed and tested the impact of private equity investment on the company's overall business performance in detail. Guan Qi (2013) took 286 companies listed on China's Growth Enterprise Market from October 2009 to December 31, 2011, as a sample and established a multiple regression model after descriptive statistical analysis and correlation analysis of the sample data. Through empirical analysis, it is found that there is no significant correlation between the number of private equity investment institutions and the operating performance of the invested companies. The nature of equity of private equity investment institutions, working time, shareholding ratio, and the number of private equity investment institutions introduced by enterprises significantly correlate

with corporate operating performance. For example, the entry of private equity investment with state-owned background could be more conducive to corporate operating performance. Improvement; the more significant the proportion of private equity investment, the worse the company's operating performance; the more companies that introduce private equity investment institutions, the operating performance will be significantly lower than other types of enterprises. In addition, in the post-IPO period of enterprises, the difference in the impact of China's private equity investment institutions and other shareholders on operating performance is not significant, and private equity investment institutions do not have a significant impact on their operating performance. Therefore, this paper proposes the hypothesis 3: the number of venture capital institutions has no substantial impact on corporate Innovation.

In China, the heterogeneity of enterprises often comes from the nature of the ownership of enterprises. The nature of enterprise ownership differs, so its management mode and financing constraints vary. Compared with non-state-owned enterprises, state-owned enterprises are more prominent in scale and have state support regarding resources and policies but often have low management efficiency (Liu Ruiming, 2013; Zhang Tianhua and Zhang Shaohua, 2016). When venture capital enters an enterprise, it will assist in terms of resources and consulting simultaneously, so state-owned and non-state-owned enterprises will have different responses to innovation activities. Therefore, this paper puts forward the hypothesis 4: venture capital institutions with state-owned backgrounds have a more prominent role in promoting enterprise innovation.

Guo Yue (2018) considered the endogenous problems caused by sample selection bias and causal effects when studying whether government subsidies have an impact on

corporate R&D investment and innovation, and combined Heckman's two-step method and two-stage least squares method (2SLS) to conduct Estimation, the basic idea is to use the first-stage regression results of the two-stage least squares method to obtain the predicted value of government subsidies, use it to replace the real government subsidies, and perform Heckman two-step regression to reduce the endogenous problems encountered in the article, instrumental variables Select the average value and growth rate of government subsidies in the industry. The regression results remain stable, and government subsidies have a significant incentive effect on R&D investment and substantive innovation. Zhou Guangsu (2018) studied the influence of the Internet on family risk financial investment behavior. To deal with endogenous problems, the article uses the average Internet access ratio at the district (county) level as an instrumental variable for personal Internet use and uses the IV Probit model to estimate. By adding the instrumental variable controls the endogeneity problem, and after adding the instrumental variable for regression, the overall result is still significant.

Review of Foreign Literature

In the research on the impact of venture capital on corporate innovation, foreign scholars first affirmed the role of venture capital in promoting corporate innovation; however, investment institutions with different backgrounds have different risk tolerances, which will also have a negative impact on corporate innovation. Bernstein et al. (2016) found that the resources given by venture capital to the invested companies improved the innovation capabilities of the companies. From the consulting perspective, venture capital institutions will participate in post-investment management and play a consulting role after entering a company. It is a manifestation of supernatural forces such as knowledge and

experience. On the one hand, venture capital institutions will help companies make R&D decisions, making the direction of innovation more transparent and improving innovation efficiency as a whole (Lahr & Mina, 2016); on the other hand, in order to facilitate future exit, venture capital institutions often Pay attention to the commercialization of innovation results, which will speed up the commercialization process of enterprise innovation and improve the ability to use innovation results. Megginson and Weiss (1991) compared 320 companies with PE investment and 320 companies without PE investment. The study found that the operating costs and daily management expenses of companies with PE participation will be reduced, which can reduce business operations to a certain extent. Costs and increase corporate profits. Among companies with investment institutions participating in the investment, such companies will pay more attention to risk control and profit level control. They usually examine the cycle's strength and hoard enough funds to deal with the black swan event during the upward cycle. Occur. Brander's (2009) research believes that PE fund investment can help stimulate the R&D and innovation capabilities of enterprises and will positively affect the improvement of enterprise value. Venture funds tend to invest in high-risk and high-return investments and will choose to suppress cutting-edge technology.

Moreover, they are willing to bear the consequences of technical risks. Therefore, enterprises receiving venture capital often have better innovation capabilities. After receiving relevant venture capital, they will also choose to continue conducting innovative research and lay out new technological directions. However, at the same time, it is also believed that venture capital institutions under the background of the government have a relatively low tolerance for risks. Coupled with the need for more supervision and

management skills in government agencies, this will also reduce the quality of corporate innovation, thereby giving birth to pseudo-innovation. Colombo (2016) believes that in the face of different types of investment institutions, market-oriented funds pursue the maximization of returns, are often more efficient, can identify good companies in the market, and guide funds to flow into good companies, thereby helping the industry to develop in good order. However, the government Most investment institutions have the task of promoting technological progress and economic development and do not care about financial returns, which may damage the investment behavior of other venture capital institutions, bring about crowding out effect, and then affect the innovation efficiency of enterprises. On this point, another scholar, Cumming & Macintosh (2006), found that the LSVCC plan of the Canadian government guidance fund did not increase the total amount of Canadian venture capital but had a crowding out effect on more social venture capital.

Chemmanur et al (2011) showed that venture capital improves the innovation level of enterprises, Caselli et al., (2009) found that venture capital has a negative impact or is not related to corporate innovation, Arqué-Castells, (2012) indicated that venture capital and corporate innovation are an "inverted U-shaped" relationship. Atanasov et al (2006) and Dessi (2011) indicated that compared with other financial intermediaries, venture capital has obvious two-sidedness. In addition to improving the business performance of start-ups through value-added services, venture capital also has a negative impact on start-ups. Grabbing behavior. Venture capital has obvious comparative advantages in providing value-added services such as supervision and governance, management consulting and resource links. Value-added services are not the only function of venture capital on corporate innovation, and venture capital may also "grab" start-ups. Its core is mainly

because the contractual arrangement between venture capital and entrepreneurs gives the former a lot of control over the contract.

Theory

Information Asymmetry Theory

The theory of information asymmetry refers to the fact that venture capital and enterprise managers have unequal access to adequate information in the market. Venture capital with a better reputation may have good news about industry development, while enterprise managers have a better understanding of the enterprise's financial situation. , leading to information asymmetry between the two parties. Venture capital institutions get more information to help listed companies make beneficial decisions because the amount of information each participant has is different from their behavioral advantages, and the decisions they make are different. Information asymmetry theory can be analyzed from two angles in the operation of venture capital: firstly, the information asymmetry between venture capital institutions and the value of listed companies. Venture capital tends to choose listed companies with promising development prospects, and listed companies also They will choose high-quality venture institutions to help them realize value enhancement; secondly, there is information asymmetry among venture capital institutions regarding the selection of high-quality investment targets and venture capital with more market information tends to choose high-quality listed companies. When venture capital participates in listed companies, all parties will consider their interests, and there is a principal-agent relationship between venture capital institutions and managers of listed companies. In the capital market, the enterprise's managers and the enterprise's operators have more information about the operation and financial information of the enterprise than

the venture capital institutions. They are in a favorable position in the information game between the two sides of the venture capital transaction. Information asymmetry theory can be further divided into "adverse selection theory," "moral hazard theory," and "signal transmission theory."

(1) Adverse selection theory

"Adverse selection theory" refers to the unequal favorable information obtained by the venture capital institution and the invested enterprise before the contract is signed. It leads to behaviors that gain information advantages and harm the interests of information-disadvantaged parties for their interests. It is a behavior of "self-selection." Often enterprise managers have more favorable information to achieve their goals. Due to the information asymmetry between venture capitalists and enterprises in the capital market and because the adverse selection of enterprises with poor performance will whitewash their business performance, venture capital institutions are often deceived and invest in enterprises with poor actual performance. Considering this problem, venture capital can stipulate the scope of rights and obligations between venture capital and business managers by creating a contract and stipulating the enterprise's expected performance standards and punitive regulations. When the enterprise fails to achieve the expected performance, Venture capital will demand compensation from the company for behaviors that are not conducive to the development of the company. This behavior can prevent business managers from cheating on venture capital.

(2) Moral Hazard Theory

"Moral Hazard Theory" means that after the manager of the listed company signs the contract with the venture capital institution, as the internal manager of the enterprise,

in order to maximize his interests, the enterprise manager will damage the interests of the venture capital, because the purposes of the two parties are different, Information asymmetry, concealment of entrepreneurs and other factors to make decisions that are not conducive to the interests of both parties. This kind of behavior not only brings a negative impact on the enterprise but also reduces the performance level of the enterprise. To prevent potential moral hazards, venture capital institutions usually sign a value adjustment mechanism agreement with the company, provide equity incentives for executives, and seek seats on the board of directors and the board of supervisors to restrain better some of the management's capital surplus management behavior, in order to obtain accurate, reliable information.

(3) Information Transfer Theory

It believes that the reputation of corporate investors or management has a specific proof effect on the company and can transmit some positive proof information to the outside world, reducing information asymmetry to a certain extent. Venture capital has a specific certification effect, which can constrain the decision-making of some earnings management behaviors and improve the quality of information disclosure. As a professional investor, venture capital can master more market information, reduce the negative impact of information asymmetry on the invested company, and pass on the company's favorable news in the capital market to other potential investors. In addition, as an influential shareholder, venture capital can participate in some critical business decisions and provide more effective management experience and better social resources; at the same time, it can effectively supervise the internal control system and business decisions of the invested companies.

Certification Supervision Theory

According to the theory of certification supervision, the participation of venture capital institutions in listed companies on the Science and Technology Innovation Board can reduce the information asymmetry between listed companies and venture capital institutions and can supervise and manage the business decisions of listed companies so that the company's value can be obtained more rational expression in market pricing.

Venture capital can use its resources to understand more internal information about the industry, and the selected invested companies have better long-term R&D and performance creation capabilities. By supervising and managing the internal governance of listed companies, venture capital institutions can reduce the information asymmetry between companies and venture capital and provide a good market environment for the operation and development of listed companies. Professional venture capital institutions invest in listed companies to make other investors in the capital market pay more attention to the company's operation and management and R&D progress and attract other investors to participate. Venture capital can convey to the market that the company's long-term development and innovation ability make the company have investment value. In addition, state-owned venture capital firms with relatively risk-free backgrounds attract more attention from institutional investors, thereby indirectly reducing the information asymmetry between firms and investors.

Facing the conflict of interests between managers of listed companies and venture capital, venture capital institutions can play the role of certification and supervision. Using their professional knowledge, venture capital institutions can identify high-quality

investment targets in the market and deliver accurate information that can reflect the value of listed companies to external investors.

Name-by-Name Hypothesis Theory

The name-by-name hypothesis holds that venture capital institutions select different investment targets due to their different professional investment levels. The best proof that high-quality venture capital institutions are to help investment targets achieve value enhancement so that venture capital institutions can exit profitably and improve the Investment reputation of venture capital institutions. However, to improve their investment reputation and level, venture capital institutions with immature qualifications will eagerly choose investment targets and participate in the operation and management of enterprises. Because of venture capital's limited professional capabilities, they will give enterprises wrong judgments. At this time, the healthy development of the invested company will also damage the reputation of venture capital institutions.

In the capital market, compared with long-established venture capital institutions with professional investment experience, short-established investment institutions with poor reputations are more likely to be motivated by performance requirements. They want to enter the business development of enterprises. However, the "famous" investment institutions have been trusted by the public, and their subsequent financing has little impact on them, so they are less likely to be eager for quick success.

Value-Added Service Theory.

The theory of value-added services holds that the participation of venture capital institutions in listed companies will bring financial support and other value-added services

to enterprises through social relationship resources, such as improving the company's internal system and improving company financing constraints. The specific manifestation is that after the establishment of the investment relationship, venture capital institutions will actively participate in the governance and supervision of the enterprise, provide management consulting based on professional capabilities and relevant industry experience, and even play a "signal function" to attract more tangible and intangible resources for the enterprise (Megginson & Weiss, 1991), the innovation efficiency and performance of enterprises will increase accordingly.

CHAPTER 3

INTRODUCTION OF MODEL

Variable Selection

This paper first selects all companies listed on the Science and Technology Innovation Board during 2019-2021 as the research object and studies the impact of venture capital institutions on the innovation of listed companies on the Science and Technology Innovation Board and the impact of venture capital background, venture capital ratio, and venture capital amount on companies. Due to careful considerations, the data in this paper are processed as follows: (1) Excluding financial listed companies. Due to the particularity of the central business of financial institutions, their primary market positioning is different from that of public enterprises, and their financial data are far from those of public enterprises, so they are excluded here; (2) Excluded from the stock market by ST and ST* Listed companies with missing classes and data. The venture capital data in this paper and the data of listed companies on the Science and Technology Innovation Board come from the Wind, Guotaian, and China Patent databases. Data in this paper were processed by Stata14, and a total of 575 observational variables were counted in the end, among which 14 variables that did not meet the standard were excluded.

Dependent Variable

1) Research and development investment (R&D): the proportion of the enterprise's research and development investment in operating income in the current year.

2) Innovation output (Patent): It take the total number of patent applications of the enterprise in that year. Since the number of patent applications cannot effectively avoid

false elements in the patent applications of enterprises when measuring R&D innovation output, in order to ensure the technical content of patents and taking into account the characteristics of innovation output in the manufacturing and information technology industries, this paper excludes the number of appearance patents, The total number of invention patents, utility model patents, and software copyright authorizations obtained by enterprises is selected instead of the number of patent applications to measure technological innovation output.

3) Proportion of R&D personnel (R&DP): The ratio of R&D personnel to the total number of employees in the year when the company is listed.

Independent Variable

1) Venture capital (VC): dummy variable. If venture capital is involved, it is 1. Otherwise, it is 0. The data of the top ten shareholders of the sample companies listed on the Science and Technology Innovation Board from 2019 to 2021 are provided through the Guotaian database. If the names of the top ten shareholders of a company listed on the Science and Technology Innovation Board contain words such as "venture investment," "innovation investment," "angel investment," and "venture capital," it is considered that the listed company has a sub-line investment background. Otherwise, it is considered that there is no venture capital participate.

2) Number of venture capital institutions (VC_M): Select the top ten shareholders listed in the company's pre-IPO prospectus as a research sample and add up the number of venture capital institutions among the top ten shareholders to represent the investment quantity of venture institutions.

3) Venture Capital Shareholding Ratio (VC_S): The ratio of venture capital investment ratio shares among the top ten shareholders of listed companies to the top ten shareholders.

4) Venture capital background (VC_B): dummy variable, 1 if the venture capital shareholder has state-owned capital, and 0 otherwise.

Control Variable

1) Enterprise size (Size): the natural logarithm of the enterprise's total assets in the current year.

2) Enterprise age (Age): It takes the logarithm of the age of the enterprise.

3) Profitability (ROA): A company's net profit ratio to its total assets.

4) Leverage ratio (Lev): The total liabilities of the enterprise divided by the total assets of the enterprise at the end of the year.

5) Cash flow ratio (Cashflow): It refers to the value obtained by comparing the cash flow with other project data. Cash flow ratio equal with net cash flow from operating activities / current liabilities at the end of the period. This ratio measures how much the cash flow generated by the company's operating activities can cover current liabilities. The higher the percentage, the better the financial flexibility of the enterprise. Due to various industries' different business natures (service-oriented, production-oriented), the net cash flow generated by operating activities varies considerably. Hence, the ratio of enterprises with other industry properties differs significantly.

6) Shareholding ratio of the largest shareholder (Top1): Number of shares held by the largest shareholder/total number.

7) Equity balance (Balance): the shareholding ratio of the second to fifth shareholders / the shareholding ratio of the largest shareholder.

Model Introduction

To test the hypothesis, analyze the participation of venture capital and the amount of venture capital, analyze the impact of investment ratio and venture capital background on corporate innovation, and build a regression model after controlling relevant variables:

$$Innov_{i,t} = \alpha_0 + \beta_0 VC_{i,t} + \beta_1 VC\_M_{i,t} + \beta_2 VC\_S_{i,t} + \beta_3 VC\_B_{i,t} + \gamma_0 size_{i,t} + \gamma_1 age_{i,t} + \gamma_2 Roa_{i,t} + \gamma_3 Lev_{i,t} + \gamma_4 Cashflow_{i,t} + \gamma_5 top1_{i,t} + \gamma_6 Balance_{i,t} + \epsilon_{i,t}$$

Among them, i and t represent the listed company and year respectively. $Innov_{i,t}$ represents the enterprise innovation of the explained variable, which can represent R&D input and innovation output respectively. $VC_{i,t}$, $VC\_M_{i,t}$, $VC\_S_{i,t}$ and $VC\_B_{i,t}$ represent explanatory variables venture capital participation, venture capital quantity, venture capital ratio and venture capital background. $size_{i,t}$, $age_{i,t}$, $Roa_{i,t}$, $Lev_{i,t}$, $Cashflow_{i,t}$, $top1_{i,t}$, $Balance_{i,t}$ are control variables.

CHAPTER 4

EMPRICIAL REGRESSION ANALYSIS

Descriptive Statistical Analysis

It can be seen from the table that there are 575 observation variables in this model. Among the explained variables, the maximum proportion of R&D personnel is 87.34, the minimum is 0.21, the average is 29.17, and the standard deviation is 17.95. It shows a significant gap in the proportion of R&D personnel of enterprises on the Science and Technology Innovation Board. The maximum balance of R&D investment is 31.72, the minimum is 0.16, the average is 8.21, and the standard deviation is 13.47. It shows that there is also a significant gap in R&D investment among the companies on the Science and Technology Innovation Board. Innovation output, that is, the number of patents owned by the company in the year, has a maximum value of 732, a minimum value of 0, an average value of 42.72, and a standard deviation of 84.95. It shows a significant gap in the innovation output of enterprises on the Sci-tech Innovation Board.

Table 1 Descriptive statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
R&DP	575	29.17	17.95	0.21	87.34
R&D	573	8.21	13.47	0.16	31.72
Patent	575	42.72	84.95	0	732
VC	575	0.53	0.50	0	1
VC_M	575	0.85	1.04	0	5
VC_S	575	3.39	5.27	0	28.96
VC_B	575	0.45	0.50	0	1
Size	575	21.55	0.85	20.00	26.16
Lev	575	0.24	0.16	0.02	1.17
ROA	575	0.08	0.11	-0.57	0.97
Cashflow	575	0.04	0.09	-0.63	0.73
Top1	575	0.31	0.14	0.09	0.83
FirmAge	575	2.73	0.34	1.61	3.71
Balance	575	1.10	0.63	0.04	3.32

Regarding the explanatory variables, the maximum value of VC is 1, the minimum value is 0, the mean is 0.53, and the standard deviation is 0.5. It shows that 53% of the companies have venture capital institutions participating in the investment, indicating that venture capital tends to be high-tech companies on the Science and Technology Innovation Board. The maximum number of venture capital institutions is 5, the minimum is 0, the average is 3.39, and the standard deviation is 1.04. It shows that the data is relatively stable. The maximum shareholding ratio of venture capital is 28.96, the minimum is 0, the average is 3.389, and the standard deviation is 5.27. In the background of venture capital companies, the maximum value is 1, the minimum value is 0, the average value is 0.45, and the standard deviation is 0.50. It shows that 45% of venture capital companies have state-owned capital as shareholders.

Correlation Analysis

Table 2 Correlation analysis between explanatory variable and explained variable

	R&DP	R&D	Patent	VC	VC_M	VC_S	VC_B
R&DP	1.00						
R&D	0.01	1.00					
Patent	-0.04	-0.02	1.00				
VC	0.03	0.03	0.12	1.00			
VC_M	0.02	-0.03	-0.08	0.77	1.00		
VC_S	0.01	0.03	0.07	0.61	0.74	1.00	
VC_B	0.03	0.03	0.11	0.86	0.74	0.57	1.00

In this paper, the Pearson correlation coefficient test is carried out on the model's core explanatory variables and explained variables. The results are shown in the table below. There is no correlation between the three defined variables. There are different positive correlations between venture capital and the three explained variables of enterprise innovation. It preliminarily verifies our hypothesis that firms with venture capital

participation are more capable of innovation. There is a positive correlation between the number of venture capital institutions participating and the proportion of R&D personnel but a negative correlation between R&D investment and the number of patents. There are different positive correlations between venture capital shareholding ratio and venture capital background with the three explained variables, which may also preliminarily explain the positive effect of venture capital shareholding ratio and venture capital background on corporate innovation.

Benchmark Regression

From the Table 3, we can see that venture capital is positively correlated with the proportion of enterprise researchers and is significant at the 1% level. This result is contrary to what we assumed in our hypothesis. It shows that STAR Market companies with venture capital participation will perform better in the proportion of researchers, thus demonstrating better innovation capabilities. It can be seen from the column (2) in Table 3 that there is a positive correlation between the amount of venture capital investment and the proportion of enterprise R&D personnel, and it is significant at the level of 5%. It shows that the more venture capital institutions participate, the higher the proportion of R&D personnel in the enterprise and the stronger the innovation ability of the enterprise. It shows that venture capital institutions can play a signal transmission function. It can be seen from the column (3) in Table 3 that there is a positive correlation between the share held by venture capital institutions and the proportion of R&D personnel in enterprises, and it is significant at the 5% level. It shows that the higher the shares held by venture capital institutions in the sci-tech innovation board enterprises, the more influential the proportion of R&D personnel in enterprises and the stronger the innovation ability of enterprises. It

shows that the involvement of venture capital institutions will bring more support to the innovation of enterprises. From Table 3 column (4), the variable coefficient of venture capital background is positive and significant at 1% level. It shows that venture capital with a state-owned environment will have a positive role in promoting the value of enterprises. State-owned venture capital institutions have rich social resources that can play a value-added service function. The proportion of R&D personnel in such enterprises will also be relatively high. In summary, when the explained variable is the proportion of R&D personnel, the four explanatory variables all show a significant positive correlation.

Table 3 Regression results of venture capital and researcher share

	(1) RDP	(2) RDP	(3) RDP	(4) RDP
VC	0.00***			
	(2.90)			
VC_M		0.01**		
		(2.43)		
VC_S			0.04**	
			(2.06)	
VC_B				0.00***
				(4.46)
Size	-0.00	-0.00	-0.00	-0.00
	(-1.24)	(-0.17)	(-0.34)	(-1.59)
Lev	0.00***	0.00***	0.00***	0.00***
	(9.98)	(9.38)	(10.05)	(8.16)
ROA	0.00***	0.00***	0.00***	0.00***
	(3.68)	(3.25)	(3.09)	(4.61)
Cashflow	-0.00	-0.00	-0.00*	0.00
	(-0.41)	(-1.20)	(-1.93)	(1.21)
Top1	0.00**	0.00**	0.00	0.00**
	(2.59)	(2.18)	(1.54)	(2.37)
FirmAge	0.01***	0.01***	0.01***	0.01***
	(5.58)	(5.14)	(5.28)	(5.88)
Balance	-0.01***	-0.01***	-0.01***	-0.01***
	(-4.46)	(-3.48)	(-3.40)	(-3.93)
_cons	2.93***	2.63***	2.96***	2.73***
	(16.20)	(15.13)	(14.53)	(16.71)
N	575	575	575	575
adj. R^2	0.99	0.99	0.99	0.99

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

From table 4 columns (1) and (2), we can see that venture capital and the number of venture capital institutions have a significant positive correlation at the level of 1% for the R&D investment of enterprises. The involvement of more venture capital may enable such enterprises to have sufficient cash flow to invest more in R&D. In column (3), the shareholding ratio of venture capital institutions is also positively related to the R&D investment of enterprises, and it is significant at the level of 5%. In column (4), the background of venture capital institutions has a negative relationship with corporate R&D investment at a group of 5%. The result is inconsistent with our hypothesis, it may be a problem about variables.

Table 4 Regression results of venture capital and R&D investment

	(1) RD	(2) RD	(3) RD	(4) RD
VC	0.00***			
	(3.57)			
VC_M		0.00***		
		(3.58)		
VC_S			0.00**	
			(0.06)	
VC_B				-0.00**
				(-0.40)
Size	-0.01***	-0.01***	-0.01***	-0.00***
	(-6.51)	(-6.40)	(-5.97)	(-5.74)
Lev	0.00	0.00*	0.00	0.00
	(0.73)	(1.82)	(1.35)	(1.41)
ROA	0.00***	0.00***	0.00***	0.00***
	(9.81)	(8.582)	(9.32)	(9.01)
Cashflow	0.00***	0.00***	0.00***	0.00***
	(6.16)	(4.45)	(5.55)	(5.20)
Top1	0.00***	0.00***	0.00***	0.00***
	(4.98)	(5.41)	(3.97)	(4.38)
FirmAge	0.00***	0.00***	0.00***	0.00***
	(12.67)	(12.43)	(11.63)	(11.60)
Balance	-0.00***	-0.00***	-0.00***	-0.00***
	(-4.68)	(-5.55)	(-3.87)	(-4.27)
_cons	0.08***	0.09***	0.08***	0.08***
	(14.67)	(15.11)	(13.44)	(14.35)
N	575	575	575	575
adj. R^2	0.36	0.36	0.32	0.32

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5 Regression results of venture capital and the patents

	(1) Patent	(2) Patent	(3) Patent	(4) Patent
VC	-0.00*			
	(-1.82)			
VC_M		-0.00**		
		(-1.53)		
VC_S			0.01**	
			(2.28)	
VC_B				0.00***
				(3.79)
Size	-0.01***	-0.01***	-0.01***	-0.01***
	(-15.88)	(-15.50)	(-15.73)	(-16.78)
Lev	-0.00***	-0.00***	-0.00***	-0.00***
	(-4.52)	(-4.66)	(-4.41)	(-5.60)
ROA	0.00	0.00	0.00	0.00**
	(1.28)	(0.96)	(1.08)	(2.37)
Cashflow	-0.00**	-0.00***	-0.00***	-0.00
	(-2.26)	(-2.96)	(-3.32)	(-0.35)
Top1	-0.00***	-0.00***	-0.00***	-0.00***
	(-4.85)	(-5.03)	(-5.41)	(-5.20)
FirmAge	0.00	0.00	0.00	0.00
	(0.71)	(0.41)	(0.64)	(0.96)
Balance	0.00	0.00	0.00	0.00
	(0.32)	(0.81)	(1.12)	(0.83)
_cons	0.17***	0.12***	0.20***	0.13***
	(3.55)	(2.64)	(3.86)	(3.18)
N	575	575	575	575
adj. R^2	0.94	0.94	0.94	0.94

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

From column (1) of the table 5, we can see that the participation of venture capital institutions and the number of corporate patents is negative at 10%, and the correlation is weak. It can be seen from column (2) that the number of venture capital institutions is significantly negative to the number of patents of enterprises at the level of 5%. In column (3), the shareholding ratio of venture capital institutions is also positively related to the number of patents of enterprises, and it is significant at the level of 5%. In column (4), the background of venture capital institutions has a positive relationship with the number of patents of enterprises at 1%. When the explanatory variable is the number of patents held

by the company, the shareholding of venture capital institutions and the background of venture capital institutions positively affect the number of patents held by the company. However, the number of venture capital institutions has a negative effect on the number of patents. Combined with the regression results of the other two explained variables, the number of venture capital institutions positively affects the defined variables, so this result does not affect our results.

Table 6 Main regression

	(1) R&DP	(2) R&D	(3) Patent
VC	0.00	55.91***	0.00***
	(1.01)	(6.14)	(3.95)
VC_M	-0.00	155.45***	0.00**
	(-0.50)	(6.04)	(2.37)
VC_S	0.018	1.13***	0.02***
	(0.62)	(7.01)	(3.11)
VC_B	0.00**	56.29***	0.00***
	(2.57)	(5.90)	(4.98)
Size	-0.00	-53.33***	-0.01***
	(-1.15)	(-3.11)	(-16.39)
Lev	0.00***	17.96***	0.00***
	(6.54)	(5.78)	(6.72)
ROA	0.00***	0.15	0.00**
	(4.78)	(0.22)	(2.23)
Cashflow	0.00	0.49	0.00
	(1.58)	(0.40)	(0.54)
Top1	0.00	8.32**	0.00***
	(1.52)	(2.16)	(6.44)
FirmAge	0.01***	-15.88**	0.00
	(5.74)	(-2.12)	(0.65)
Balance	0.01***	38.85**	0.00**
	(2.72)	(2.29)	(2.51)
_cons	2.61***	3.44***	0.11**
	(11.52)	(27.20)	(1.98)
N	575	573	575
adj. R^2	0.99	0.99	0.94

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Finally, we ran benchmark regressions on all four variables simultaneously. It can be seen from the results that venture capital (VC), the number of venture capital institutions

(VC_M), the shareholding ratio of venture capital institutions (VC_S), and the venture capital background (VC_B) have significant effects on R&D investment and the number of patents. It can be found that the shareholding ratio of venture capital institutions (VC_S) has the most significant impact on R&D investment and the number of corporate patents. In contrast, venture capital (VC) has the most negligible effect on the two explained variables. In addition, venture capital (VC), the number of venture capital institutions (VC_M), and the shareholding ratio of venture capital institutions (VC_S) are not significant among the explanatory variables of the proportion of R&D personnel. In contrast, venture capital background (VC_B) does not significantly affect the balance of R&D personnel. The balance is exceptionally buoyant at the 5% level. The reason for such a result is that under China's national conditions, state-owned investment institutions are strong, and they profoundly impact enterprises' innovation and development.

In addition, from the regression results of other control variables, it can be seen that the size of the assets of listed companies has a negative effect on corporate innovation, which means that the larger the scale of the company, the less investment in innovation. The company's asset-liability ratio index is significantly positive, indicating that the size of the listed company's asset-liability ratio will promote the improvement of the company's innovation. The company's profitability and cash flow ratio also positively impact corporate innovation. The stronger the company's profitability, the greater the promotion effect on the company's innovation level. The company has sufficient funds to support the creation of enterprises. The degree of equity balance and the shareholding ratio of the largest shareholder is both positive and significant, significantly promoting the enterprise's value.

Based on the above analysis results, the intervention of venture capital can play a significant positive role in the value-added of companies listed on the Science and Technology Innovation Board. The research results show that venture capital can effectively play the role of certification supervision and signal transmission. That is, venture capital can use its own professional management experience to supervise the innovation of listed companies and provide suggestions for the company's major decisions. At the same time, it conveys favorable news to the market and attracts other social funds to promote the operation and development of listed companies, thereby significantly improving corporate innovation.

Endogeneity Test

Due to the existence of endogeneity, the results of benchmark test alone cannot verify whether the increase in enterprise innovation activities after venture capital entry is since venture capital selects companies with stronger innovation ability or more innovative potential, or the help of venture capital to enterprises makes their innovation activities increase. Therefore, the propensity score matching method will be adopted in this section to solve the endogeneity problem.

To enhance the stability of the results, we use the propensity score matching (PSM) method for testing. This paper uses the logit model to calculate the propensity score of each company, and the control variables selected by Wen and Feng (2018) include total assets, asset-liability ratio, return on assets, cash flow rate, company age, shareholding ratio of the largest shareholder and equity balance degree. According to the calculated propensity score, the nearest neighbor matching method is used to match the enterprises 1 to 1.

By using the PSM method, this paper constructs a new control group for firms supported by equity investment institutions. After matching, the t-test indicated that there was no statistically significant difference in the main indicators between the treatment and control groups.

Table 7 Deviation changes of control group and treatment group after the most neighboring matching treatment

Variable		Mean		Deviation variation		t-test	
		Treatment	Control	Value	Rate(%)	t	p>|t|
Size	Before	7.33	7.21	13.7		3.09	0.00
	After	7.33	7.29	4.9	64	1.22	0.22
Lev	Before	0.26	0.24	12.5		2.83	0.01
	After	0.26	0.26	3.5	72	0.82	0.42
Roa	Before	0.07	0.06	-7.7		-1.73	0.08
	After	0.07	0.07	-5.1	33.1	-1.22	0.22
Cashflow	Before	0.26	0.25	2.7		0.61	0.54
	After	0.26	0.25	5.3	-96.2	1.22	0.22
Top1	Before	0.21	0.20	12.9		2.91	0.00
	After	0.22	0.21	5.1	60.5	1.28	0.20
FirmAge	Before	13.56	12.87	12.3		2.79	0.01
	After	13.56	13.67	-1.9	84.7	-0.45	0.65
Balance	Before	0.05	0.05	17.4		3.93	0.01
	After	0.06	0.06	-3.1	82.4	-0.64	0.53

Note: The deviations in the table are calculated as $(X_T-X_C)/\sigma_t$, where x_t and x_c are the mean values of the relevant variables for the treatment group and the control group, respectively, and σ_t is the standard error of the relevant variables for the treatment group. The reduction rate is the percentage change between the absolute value of the initial deviation and the absolute value of the deviation treated by various methods.

Then, using PSM-matched samples, regression was performed again, and the results were shown in Table 8. The difference between Table 8 and Table 6 is that Table 7 uses the PSM matched sample, while Table 6 uses the complete sample. Comparing with the baseline regression result, it can be found that the absolute value of the regression result obtained using the PSM sample is smaller. This indicates that endogeneity amplifies the positive correlation between venture capital entry behavior and enterprise innovation activities, that is, venture capital will indeed choose enterprises with high innovation

intensity for investment. However, excluding this selection effect, the entry of venture capital will also promote the innovation of enterprises.

Table 8 Main regression (PSM matched sample)

	(1) R&DP	(2) R&D	(3) Patent
VC	0.00*	9.53***	0.05***
	(0.14)	(4.78)	(3.56)
VC_M	-0.01	87.24***	0.02**
	(-0.12)	(25.68)	(2.38)
VC_S	0.02	53.27**	0.01***
	(1.98)	(19.32)	(1.38)
VC_B	0.03*	0.08**	0.00***
	(2.43)	(1.23)	(0.24)
Control Variable	YES	YES	YES
Observation	428	428	428
R^2	0.31	0.45	0.57
Year FE	YES	YES	YES

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Heterogeneity Analysis

To further test the impact of venture capital on corporate innovation, this paper divides the listed companies on the Science and Technology Innovation Board into six industries by industry. Only the pharmaceutical manufacturing sector, professional equipment manufacturing industry, and information technology service industry have sufficient data for heterogeneity analysis.

The table 9 takes the proportion of R&D personnel as the explained variable for heterogeneity analysis. For the pharmaceutical manufacturing industry, there is a significant positive correlation between venture capital (VC), venture capital institution shareholding ratio (VC_S), venture capital institution background (VC_B) and the proportion of R&D personnel at the level of 1%. The number of venture capital institutions

(VC_M) is positively correlated with the balance of researchers at the level of 10%, and the correlation is weak.

Table 9 Heterogeneity analysis of the proportion of R&D personnel

	Medicine R&DP	Special Equipment R&DP	Information service R&DP
VC	0.01***	0.00*	0.03***
	(4.48)	(1.78)	(4.43)
VC_M	0.01*	0.01**	0.09***
	(1.79)	(2.46)	(4.99)
VC_S	0.18***	0.03	0.18***
	(3.24)	(1.07)	(3.06)
VC_B	0.01***	0.00*	0.02**
	(4.77)	(1.84)	(2.28)
Size	0.02**	-0.00**	0.05***
	(2.55)	(-1.99)	(3.17)
Lev	0.00***	0.00***	0.00
	(4.40)	(3.57)	(0.75)
ROA	0.00	0.00***	0.00
	(1.20)	(3.37)	(1.41)
Cashflow	-0.00	0.00	0.00**
	(-1.17)	(1.40)	(2.30)
Top1	-0.00	-0.00	0.01*
	(-0.68)	(-0.12)	(1.84)
FirmAge	0.01***	0.00**	0.02**
	(2.93)	(2.56)	(2.33)
Balance	-0.00	-0.00	0.00
	(-0.06)	(-0.73)	(0.15)
_cons	2.25***	4.27***	-6.59
	(6.10)	(3.76)	(-1.63)
N	114	317	89
adj. R^2	0.99	-0.53	0.65

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

For the special equipment manufacturing industry, there is a significant positive correlation between the number of venture capital institutions (VC_M) and the proportion of R&D personnel at a level of 5%. Venture capital (VC) and venture capital institutional background (VC_B) are positively correlated with the proportion of researchers at the level of 10%, and the correlation is weak. However, there is no correlation between the shareholding ratio of venture capital institutions (VC_S) and the proportion of R&D

personnel. For the information technology service industry, there is a significant positive correlation between venture capital (VC), the number of venture capital institutions (VC_M), the shareholding ratio of venture capital institutions (VC_S) and the proportion of R&D personnel at the level of 1%. The background of venture capital institutions (VC_B) positively correlates with the balance of researchers at the level of 5%.

Table 10 Heterogeneity analysis of R&D investment

	Medicine R&D	Special Equipment R&D	Information service R&D
VC	-0.00	0.00***	0.00***
	(-1.43)	(10.76)	(3.74)
VC_M	-0.00	0.00***	0.00***
	(-0.42)	(10.98)	(4.18)
VC_S	-0.00	0.00***	0.00***
	(-0.19)	(8.20)	(4.69)
VC_B	-0.00	0.00***	0.00***
	(-1.94)	(10.24)	(5.20)
Size	0.00	-0.00***	-0.00*
	(0.72)	(-9.64)	(-1.77)
Lev	0.00***	0.00***	0.00***
	(3.51)	(17.50)	(8.30)
ROA	0.00	0.00***	0.00***
	(1.66)	(27.05)	(38.29)
Cashflow	-0.00	0.00***	0.00***
	(-0.36)	(19.09)	(20.11)
Top1	0.00	0.00	-0.00*
	(0.96)	(0.65)	(-1.97)
FirmAge	0.01***	0.00***	0.00
	(5.20)	(8.06)	(1.25)
Balance	-0.00	0.00	0.00**
	(-0.79)	(1.07)	(2.46)
_cons	0.12***	0.00***	0.00
	(7.54)	(8.64)	(0.62)
N	114	317	89
adj. R^2	0.84	0.91	0.98

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The table 10 takes the proportion of enterprise R&D investment as the explained variable for heterogeneity analysis. For the pharmaceutical manufacturing industry, there is no correlation between venture capital (VC), the number of venture capital institutions

(VC_M), the shareholding ratio of venture capital institutions (VC_S), the background of venture capital institutions (VC_B) and the proportion of R&D investment. For the special equipment manufacturing industry, venture capital (VC), the number of venture capital institutions (VC_M), the shareholding ratio of venture capital institutions (VC_S), the background of venture capital institutions (VC_B) and the proportion of R&D personnel are below 1%, showing a significant positive correlation. For the information technology service industry, venture capital (VC), the number of venture capital institutions (VC_M), the shareholding ratio of venture capital institutions (VC_S), the background of venture capital institutions (VC_B) and the proportion of R&D personnel are below 1%. It shows a significant positive correlation.

The table 11 uses the number of patents of enterprises as the explained variable for heterogeneity analysis. For the pharmaceutical manufacturing industry, venture capital (VC), the number of venture capital institutions (VC_M), the shareholding ratio of venture capital institutions (VC_S), the background of venture capital institutions (VC_B) and the number of enterprise patents are significant positive at the level of 1%. For the special equipment manufacturing industry, there is no correlation between venture capital (VC), the number of venture capital institutions (VC_M), the shareholding ratio of venture capital institutions (VC_S), the background of venture capital institutions (VC_B) and the number of enterprise patents. For the information technology service industry, a significant positive correlation exists between venture capital (VC), venture capital institutional background (VC_B) and the number of enterprise patents at 1%. There is a significant positive correlation between the shareholding ratio of venture capital institutions (VC_S) and the

number of enterprise patents at 5%. However, there is no correlation between the number of venture capital institutions (VC_M) and the number of corporate patents.

Table 11 Heterogeneity analysis of enterprise patent quantity

	Medicine Patent	Special Equipment Patent	Information service Patent
VC	0.00***	-0.00	0.00***
	(5.18)	(-0.02)	(3.36)
VC_M	0.01***	-0.00	0.00
	(4.99)	(-0.45)	(1.26)
VC_S	0.03***	-0.00	0.01**
	(4.25)	(-0.31)	(2.33)
VC_B	0.00***	-0.00	0.00***
	(6.11)	(-0.17)	(3.29)
Size	-0.01***	-0.01***	-0.01***
	(-5.55)	(-13.39)	(-5.97)
Lev	-0.00	-0.00***	-0.00*
	(-1.48)	(-5.41)	(-1.73)
ROA	0.00	0.00***	0.00***
	(0.69)	(5.30)	(3.46)
Cashflow	-0.00	0.00***	0.00
	(-1.51)	(4.27)	(0.90)
Top1	-0.00*	-0.00***	-0.00***
	(-1.70)	(-7.33)	(-3.79)
FirmAge	0.00***	0.00	0.00
	(3.19)	(1.37)	(0.89)
Balance	-0.00	0.00***	0.00**
	(-0.31)	(3.81)	(2.48)
_cons	0.08	2.40***	0.20
	(1.56)	(4.95)	(0.71)
N	114	317	89
adj. R^2	0.99	0.50	0.49

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

To sum up, for the pharmaceutical manufacturing industry, special equipment manufacturing industry and information technology service industry, venture capital (VC), the number of venture capital institutions (VC_M), the shareholding ratio of venture capital institutions (VC_S), the background of venture capital institutions (VC_B) These four explanatory variables can all promote the innovation of related enterprises.

Table 12 Heterogeneity Analysis – Medicine

	Medicine R&DP	Medicine R&D	Medicine Patent
VC	0.01***	-0.00	0.00***
	(4.48)	(-1.43)	(5.18)
VC_M	0.01*	-0.00	0.01***
	(1.79)	(-0.42)	(4.99)
VC_S	0.18***	-0.00	0.03***
	(3.24)	(-0.19)	(4.25)
VC_B	0.01***	-0.00	0.00***
	(4.77)	(-1.94)	(6.11)
Size	0.02**	0.00	-0.01***
	(2.55)	(0.72)	(-5.55)
Lev	0.00***	0.00***	-0.00
	(4.40)	(3.51)	(-1.48)
ROA	0.00	0.00	0.00
	(1.20)	(1.66)	(0.69)
Cashflow	-0.00	-0.00	-0.00
	(-1.17)	(-0.36)	(-1.51)
Top1	-0.00	0.00	-0.00*
	(-0.68)	(0.96)	(-1.70)
FirmAge	0.01***	0.01***	0.00***
	(2.93)	(5.20)	(3.19)
Balance	-0.00	-0.00	-0.00
	(-0.06)	(-0.79)	(-0.31)
_cons	2.25***	0.12***	0.08
	(6.10)	(7.54)	(1.56)
N	114	114	114
adj. R^2	0.99	0.84	0.99

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

For pharmaceutical manufacturing enterprises, the four explanatory variables have a significant promoting relationship with the proportion of R&D personnel and the number of patents but have no significant relationship with the proportion of R&D investment. This may be because the proportion of R&D investment in pharmaceutical companies is mainly affected by many factors such as the company's own technical strength, product research and development cycle, and market competition, rather than simply depending on the degree of venture capital involvement. Therefore, its effect may be interfered with or offset

by other factors. The significant impact of venture capital on the proportion of R&D personnel and the number of patents may be due to the fact that venture capital institutions usually have rich industry experience and resource networks, and can provide value-added services such as strategic guidance, market analysis and technology evaluation for the invested enterprises, so as to help enterprises better conduct R&D activities and increase the proportion of R&D personnel and the number of patents.

Table 13 Heterogeneity Analysis - Specialized equipment

	Special Equipment R&DP	Special Equipment R&D	Special Equipment Patent
VC	0.00*	0.00***	-0.00
	(1.78)	(10.76)	(-0.02)
VC_M	0.01**	0.00***	-0.00
	(2.46)	(10.98)	(-0.45)
VC_S	0.03	0.00***	-0.00
	(1.07)	(8.20)	(-0.31)
VC_B	0.00*	0.00***	-0.00
	(1.84)	(10.24)	(-0.17)
Size	-0.00**	-0.00***	-0.01***
	(-1.99)	(-9.64)	(-13.39)
Lev	0.00***	0.00***	-0.00***
	(3.57)	(17.50)	(-5.41)
ROA	0.00***	0.00***	0.00***
	(3.37)	(27.05)	(5.30)
Cashflow	0.00	0.00***	0.00***
	(1.40)	(19.09)	(4.27)
Top1	-0.00	0.00	-0.00***
	(-0.12)	(0.65)	(-7.33)
FirmAge	0.00**	0.00***	0.00
	(2.56)	(8.06)	(1.37)
Balance	-0.00	0.00	0.00***
	(-0.73)	(1.07)	(3.81)
_cons	4.27***	0.00***	2.40***
	(3.76)	(8.64)	(4.95)
N	317	317	317
adj. R^2	-0.53	0.91	0.50

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

For the special equipment manufacturing industry, the four explanatory variables have a significant promoting effect on the proportion of R&D personnel and the proportion

of R&D investment, but the impact on the number of patents is not significant. This may be since the research of professional equipment requires a lot of time investment, and companies are not able to obtain a large number of new patents in a period of 1-2 years. While the Science and Technology Board was established in 2019, most of the companies we collected only have two years of data. Therefore, the result that venture capital has no significant effect on the number of patents of professional equipment enterprises has been reasonably explained.

Table 14 Heterogeneity Analysis - Information service

	Information service R&DP	Information service R&D	Information service Patent
VC	0.03***	0.00***	0.00***
	(4.43)	(3.74)	(3.36)
VC_M	0.09***	0.00***	0.00
	(4.99)	(4.18)	(1.26)
VC_S	0.18***	0.00***	0.01**
	(3.06)	(4.69)	(2.33)
VC_B	0.02**	0.00***	0.00***
	(2.28)	(5.20)	(3.29)
Size	0.05***	-0.00*	-0.01***
	(3.17)	(-1.77)	(-5.97)
Lev	0.00	0.00***	-0.00*
	(0.75)	(8.30)	(-1.73)
ROA	0.00	0.00***	0.00***
	(1.41)	(38.29)	(3.46)
Cashflow	0.00**	0.00***	0.00
	(2.30)	(20.11)	(0.90)
Top1	0.01*	-0.00*	-0.00***
	(1.84)	(-1.97)	(-3.79)
FirmAge	0.02**	0.00	0.00
	(2.33)	(1.25)	(0.89)
Balance	0.00	0.00**	0.00**
	(0.15)	(2.46)	(2.48)
_cons	-6.59	0.00	0.20
	(-1.63)	(0.62)	(0.71)
N	89	89	89
adj. R^2	0.65	0.98	0.49

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

For information service companies, the impact of venture capital involvement, shareholding ratio and investor background on the proportion of R&D personnel, R&D investment ratio and the number of patents is usually significant. However, in some cases, the impact of the number of individual VC on the number of patents may not be significant, which may be related to the randomness and uncertainty of patent applications, competition and cooperation mechanisms among VC, and other influencing factors. Therefore, in the follow-up research, it is necessary to consider the role of various factors and the complex interaction between them.

CHAPTER 5

CONCLUSIONS AND SUGGESTIONS

Empirical Conclusions

Innovation has recently attracted the attention of academics and policymakers, and venture capital institutions are considered essential in promoting company establishment and innovation. China has also recently implemented many preferential policies for venture capital institutions. Therefore, based on the current national conditions, this article discusses whether venture capital institutions have promoted enterprise innovation activities and how venture capital institutions have promoted enterprise innovation activities, aiming to provide some reference for China's venture capital policies.

First of all, this paper selects companies listed on the Science and Technology Innovation Board from 2019 to 2021, using the proportion of R&D personnel of enterprises, the proportion of R&D investment of enterprises and the number of patent applications as dependent variables, the entry of venture capital, the number of venture capital institutions, the number of venture capital. The proportion of institutions and the background of venture capital institutions are used as independent variables for regression analysis. The results show that venture capital will significantly promote the innovation activities of enterprises. Secondly, this paper verifies that venture capital has a selective effect on promoting enterprise innovation by sub-sample regression according to industry attributes. Different degrees of venture capital participation have different degrees of promotion of enterprise innovation activities.

Suggestions

To effectively play the role of venture capital in promoting China's strategic emerging industries and high-tech industries, this paper puts forward the following suggestions:

Government

The government should actively play a supporting and guiding role, promote the development of the venture capital industry, and stimulate the vitality of the private capital venture investment field by participating in venture capital institutions and providing venture capital institutions with financing facilities. In terms of promoting the investment relationship between venture capital institutions and invested companies, the government should support venture capital institutions' investment in state-owned enterprises and high-tech companies to maximize the role of venture capital in promoting innovation. To make the consulting channel play a smooth role, venture capital institutions of different natures should actively participate in the post-investment management of the invested companies and use their experience to guide the invested companies to allocate resources better and improve innovation performance.

In addition, the regulatory authorities should optimize the listing review content. Regulatory authorities should strictly control the pre-listing review of the Science and Technology Innovation Board, not only considering the profitability of enterprises but also taking R&D and innovation capabilities and future growth potential as the actual content of the review to promote venture capital institutions and enterprises to pay attention to and do their best to improve R&D and innovation of enterprises ability.

Enterprise

Enterprises should establish a complete information disclosure system to eliminate the information asymmetry between the two investors, reduce the management cost of venture capital, comprehensively use the consulting function of venture capital, and fully cooperate with the post-investment management of venture capital institutions. Reasonably allocate the company's innovation resources to avoid the occurrence of "short-term profit-seeking" and other phenomena so that venture capital can better serve the company's long-term development.

Start-up enterprises should choose venture capital institutions that meet their needs. For the start-up enterprises introducing venture capital, the long-term influence of the experience and characteristics of different venture capital institutions on the enterprise resource network and technological innovation should be fully considered. Furthermore, the most suitable venture capital institutions should be selected. Enterprises should establish a perfect information disclosure system to eliminate the problem of information asymmetry between the two investors. Enterprises can make full use of the resources of investment institutions to achieve progress.

Venture Capital Institutions

Venture capital institutions should appropriately improve their industry-specific investment capabilities. In the environment where China's economy has entered a slow growth state, the return on investment is low, and the competition among venture capital institutions is increasingly fierce. Venture capital institutions should enhance their core competitiveness in professional technology, service, and brand to obtain higher investment returns. In the process of accompanying the growth of the enterprise to reap higher returns.

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