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TRANSFORMING ENTERPRISES THROUGH VENTURE CAPITAL: A COMPREHENSIVE ANALYSIS"

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Abstract

Venture capital plays a pivotal role in fostering enterprise innovation by providing essential financial support and post-investment services. In today's dynamic business landscape, it has become a cornerstone of enterprise innovation system development. This study delves into the profound impact of venture capital enterprises in Qingdao, China, on fostering innovation within the high-tech industry. Statistics reveal that the majority of enterprises registered in China's domestic market boast venture capital/private equity backgrounds, indicating the significant role of venture capital in driving innovation. Notably, computer technology, information technology, and medical and health processes are sectors where venture capital has made substantial investments. Beyond financial backing, venture capital firms actively engage in the management and operation of their portfolio companies, offering valuable support and supervision to ensure the standardized functioning of research and development, production, internal controls, and other crucial activities. This systematic analysis of venture capital's role in fostering innovation is instrumental in guiding both venture capital practices and enterprise innovation initiatives, ultimately contributing to the overarching goals of innovation-driven development and high-quality economic growth.

Introduction

Enterprise innovation is the driving force for enterprises to gain growth momentum and competitive advantage, which not only depends on the technical resources and ability level of enterprises themselves, but also depends on the supporting ability of external innovation system. Venture capital has become an indispensable content of enterprise innovation system construction. Especially for new startups with scarce capital and low requirements for enterprise legitimacy, the institutional introduction of Qingdao venture capital enterprises can not only solve the shackles of enterprise development bottlenecks, but also provide enterprises with targeted and characteristic

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post-investment service support[1]. Venture capital mechanism is indispensable for the effectiveness of enterprise innovation. According to the statistics of investment institutions, in 2022, 403 of the 511 enterprises registered in China's domestic enterprise market have VC/PE background, and the investment share of venture capital directly invested in enterprises has exceeded 78.86%, while the share of venture capital investment in listed enterprises on the science and technology innovation board has also reached 95.12%. Among them, the investment share of computer, information technology and its intelligence, medical and health process and its intelligence and other fields has exceeded 65%, and the rapid development and change of Qingdao Venture Capital Co., Ltd. has become an important promotion of China's high-tech industry innovation and the implementation of China's innovation-driven development policy[2-5]. Venture capital intervention can not only provide initial financial support for entrepreneurial enterprises, but also participate in the operation and management activities of invested enterprises by appointing directors and supervisors, providing value-added services and supervision and control for enterprises (Wu You and Dong Jing, 2022), so as to ensure the standardized operation of R&D innovation, production and operation, internal control and other activities of enterprises. Therefore, a systematic analysis of the innovation effect of venture capital management participation is conducive to guiding venture capital and enterprise innovation practice, and giving full play to the positive role of venture capital in serving the real economy, serving innovation-driven development strategy, and serving high-quality development.

At present, domestic and foreign scholars have paid close attention to the impact of venture capital on enterprise innovation and conducted a large number of empirical studies, but the conclusions are quite different. The research results show that venture capital and enterprise innovation have a positive promotion [6], reverse inhibition, Nonlinear relationship[7], no correlation and other four scenarios. In order to provide a strong explanation for the differences in the above research conclusions, many scholars mainly focus on the influence of three factors: First, the characteristics of venture capital, such as venture capital organizational structure , equity background, investment strategy, reputation level , network centrality , etc. Second, the characteristics of entrepreneurial enterprises, such as corporate absorptive capacity, cross-organizational learning ability, etc. The third is the organizational relationship between venture capital and enterprises, such as the harmonious relationship between venture capital and invested enterprises and the matching degree. In addition, due to the internal agency risk, external operation risk and management risk caused by venture capital investors' involvement in the operation of start-up enterprises, venture capital enterprises can also improve the supervision and control of enterprises by means of management participation when providing value-added services for the investment of start-up enterprises, so as to reduce these risks. The research results on the impact of venture capital management participation on enterprises are mainly divided into the following categories: First, the involvement of venture capital enables the board of directors to participate in the internal business decision-making activities of the enterprise, supervise the business operation and management activities of the enterprise and provide consulting suggestions, thus enhancing the value of the enterprise and its innovation ability[8]. Second, the participation of venture capital management will affect the level of corporate governance, such as changing the senior management team of enterprises, strengthening the earnings management of enterprises, and reducing the illegal behavior of enterprises[9]. Third, participation in venture capital management will affect the strategic choice of enterprises. For example, participation in venture capital management will affect the IPO underpricing rate of enterprises, and the impact degree of venture capital in different backgrounds is different. At the same time, venture capital can provide a wide range of value-added services and supervision and control for entrepreneurial enterprises, thus affecting the commercial innovation and basic innovation of enterprises[10].

To sum up, the results of venture capital and enterprise innovation are very different, but most of the current data focus on the characteristics of venture capital, the characteristics of innovative enterprises and the organizational relationship between the two factors to analyze the differences in results, and the role of institutional management participation in venture capital on enterprises is limited to management performance, internal management, strategy formulation and other fields. At the same time, in the context of vigorously promoting the development of digital economy, some scholars began to focus on the impact of enterprise digital transformation on innovation. The digital transformation of enterprises is conducive to improving enterprise operation efficiency, obtaining government subsidies and increasing market attention, thus improving enterprise innovation output and innovation efficiency. In terms of innovation classification, enterprise digital transformation contributes to enterprise breakthrough innovation [11], open innovation and business model innovation. At present, there are relatively few studies on the inconsistency of the conclusion that venture capital affects enterprise innovation based on the overall framework of governance factors and digital network factors between venture capital and invested enterprises. In view of this, this paper mainly discusses the following two questions: First, what impact does venture capital management participation have on enterprise innovation? Second, in the context of the development of digital economy, what moderating effect does the intensity of digital transformation of start-ups have on the innovation effect of venture capital management participation? To solve the above problems, this paper will take the data of listed enterprises involved in Shanghai and Shenzhen A-share venture capital investment from 2004 to 2020 as the initial sample, and analyze the effect of venture capital management participation on enterprise innovation and the regulatory effect of digital transformation from A theoretical and empirical perspective[12].

The contributions of this paper are mainly reflected in the following aspects: First, it makes up for the shortcomings of the existing literature in general analysis of the impact of venture capital management participation on enterprise performance and governance. This paper mainly analyzes the impact of venture capital management participation on enterprise innovation, so as to provide a new dimension judgment for the results of venture capital management participation. Second, the existing literature is expanded to explain the limitations of venture capital institutions' influence on enterprise innovation mainly from factors such as the characteristics of venture capital and the characteristics of entrepreneurial enterprises. This paper mainly analyzes the differences of venture capital management's participation in influencing enterprise innovation from the perspective of enterprise digital transformation, so as to provide new contextual observations for verifying the relationship between venture capital management and enterprise innovation.

1. Theoretical analysis and research hypothesis

2.1. Research on the impact of venture capital management participation on enterprise innovation

Compared with mature enterprises with strong capital that have achieved original accumulation in the market, the support of venture capital is particularly critical for start-ups. As newcomers to the industry, start-ups are usually limited by their own scale and network influence, joint venture partners, and lack of R&D equipment, and the intervention of venture capital can alleviate the dilemma of Liability of Newness of start-ups to a certain extent. The injection of sufficient venture capital can not only ensure the normal operation of start-up enterprises, but also promote the innovation and development of enterprises. It has a far-reaching impact on the improvement of brand value and competitiveness, risk screening, internal governance and other supervision and control, strategic planning and listing financing. However, there are also technological risks, market risks, policy risks, financial risks, management risks, etc. in the process of enterprise innovation. Therefore, venture investors need to take appropriate measures to participate in the daily operation and management of start-up enterprises to ensure the

smooth development of enterprise innovation and the profitability of their own investment. The main ways for venture capital management to participate in influencing enterprise innovation are as follows:

2.1.1. Management participation is an important form of venture capital providing value-added services for start-ups.

First, venture capital can formulate an innovative strategy conducive to the long-term development of the enterprise by analysing its own advantages and the current situation of the industry. Venture capital often accumulates experience and expertise in specific industries, and has a deep prediction of the development status, core technology and business prospects of the industry. By assigning directors to the strategic decision-making level of the enterprise, venture capital institutions can more quickly convey cutting-edge information to the management of the enterprise, help them accurately judge the development trend of the industry, and formulate suitable innovative strategic plans, so as to seize business opportunities. Second, through strategic cooperation with venture capital institutions, start-ups often gain advantages in innovative resources. Venture capital institutions have mature social relations. In their long-term investment and operation process, they have established good network interconnection and offline cooperation with governments at all levels, upstream and downstream suppliers, securities companies, firms, etc. This has a multi-facetted impact on the development of start-up companies. On the one hand, venture capital institutions can better provide enterprises with the strategic resources needed at all stages and recruit talents to meet the innovation needs of enterprises. On the other hand, venture capital institutions can evaluate and improve the professional level of core technical personnel by participating in the daily management of enterprise management, which to a certain extent reduces the shortcomings of the enterprise itself. The innovation risk.

2.1.2. Management participation is the main means for venture capital to supervise and control start-up enterprises.

First, through venture capital management, start-up enterprises can effectively curb the possible self-interested behaviour of management and reduce the expenses of consulting audit firms in the later stage. At the same time, through diversified external supervision measures, venture capital has strengthened the innovative control system established by start-up enterprises themselves, ensuring the development of all stages in accordance with the established scientific process, and reducing the risk of internal violations. Second, the participation of venture capital can help start-ups establish a relatively complete internal management system in the initial stage, scientifically improve the incentive and restraint mechanism, formulate an interest distribution system that meets the expectations of talents in various projects, and ensure the normal operation of start-ups.

Hypothesis H1: Venture capital management participation of invested enterprises promotes enterprise innovation.

2.2. Management participation, digital transformation and enterprise innovation

The digital economy has increasingly become a key force for the reorganisation of resource factors, the reshaping of economic structure and the reconstruction of the competitive pattern. It has become a new industry trend for start-ups to realise digital organisational restructuring. Digital transformation is not only limited to production methods and marketing means, but also applies digital technology with strong compatibility and wide penetration to the enterprise's organisational structure, technical lines and other aspects to intelligently upgrade the enterprise's industrial chain. At the same time, the wide application of digital technology makes up for the information asymmetry between enterprises and between enterprises and the market, and promotes the communication and exchange of innovative information in the industry and the win-win cooperation of innovative participants. At the same time, the application of digital technology has enabled start-up enterprises to get rid of the constraints of time and space to a large extent, and the access to innovative resources has been expanded.

Enterprises have improved the overall innovation level by adjusting their own innovation input, innovation output and innovation efficiency. Therefore, based on the venture capital management participation mechanism, the adjustment effect of the digital transformation of start-up enterprises is mainly reflected in the following aspects:

2.2.1. The digital transformation of start-up enterprises reduces the cost of management participation of venture capital institutions.

First, the transportation cost of venture capital organisations participating in the daily operation and management of enterprises is reduced. The digital transformation of enterprises and the establishment and application of digital communication platforms have reduced the cost of traditional face-to-face communication. At the same time, venture capital institutions have participated in the formulation and implementation of enterprise strategies to a greater extent through communication platforms and network connections, enhancing the cooperation between the two sides and reducing the risk of errors. Second, the cost of information collection involved in venture capital management is reduced. When obtaining external financing, enterprises have the advantages of both hard information and soft information. Hard information includes information that can be directly obtained through public channels such as financial status, external ratings, business plans, etc., while soft information refers to information that is difficult to collect and process in accordance with standardised methods, and difficult to code and transmit in writing. Through digital transformation, hard information and soft information are better stored, tracked and queried, reducing the cost of obtaining information resources and improving the efficiency of information dissemination.

2.2.2. The digital transformation of start-up enterprises has enhanced the effect of management participation of venture capital institutions

First, start-up enterprises have improved the communication quality and efficiency of venture capital institutions through digital transformation. The qualitative change of communication methods has greatly enhanced the contact between start-up enterprises and the government and superior-level suppliers, which is conducive to the complementarity and mutual assistance of key resources and the sharing and exchange of core technologies. At the same time, the digital transformation of enterprises helps venture capital institutions to supervise the production and operation of various industrial chains within enterprises, effectively reducing the cost of communication between the two sides. Second, digital transformation is conducive to the in-depth excavation of highly heterogeneous information and knowledge between innovation subjects, and improves the possibility of independent research and development and innovation of enterprises. At the same time, venture capital institutions can track the innovation process of enterprises in real time through the digital technology platform, ensuring the reasonable and efficient progress of the innovation process, so that Provide professional and specialised services for enterprises.

Hypothesis H2: With the improvement of the degree of digital transformation of start-up enterprises, the innovation promotion effect of venture capital on the management participation of invested enterprises is enhanced.

2. Model design

In order to verify the impact of venture capital implementation management on corporate innovation, this paper first constructs the following benchmark regression model:

$$Inno_{i,t+1}=\alpha_0+\beta_m Mag_{ij,t}+\beta cConi,t+\varepsilon_{i,t} \quad (1)$$

In order to further investigate whether the digital transformation of enterprises will affect the willingness and effect of venture capital institution management participation, and then promote the innovation output and innovation efficiency of enterprises, the following regression model is continued to be set:

$IIIIIIIIii,tt+1=\alpha\alpha 0+\beta\beta mmMMMMMMiiii,tt+\beta\beta aaDDDDMMDDDDMMDDii,tt+\beta\beta aaaaDDDDMMDDD DMMDDii,tt*MMMMMMiiii,tt+\beta\beta ccCCIIIIii,tt+\varepsilon\varepsilon ii,tt$ (2)

In model (1) and model (2), Innoi,t+1 is the innovation scale (Inno_pati,t+1)and innovation efficiency (Inno_effi,t+1)of listed company i in year t+1, $Mag_{ij,t}$ $Con_{i,t}$ is the control variable of this article, which is used to characterize the characteristics of entrepreneurial enterprises and venture capital, including enterprise size, enterprise age, return on assets, current ratio, cash flow , asset-liability ratio, profit margin, age of venture capital institutions, equity ratio of venture capital institutions, etc.;εi,t is the error term of this paper. Correspondingly, in model (2), Digitali,t is the degree of digital transformation of enterprise i, and the control variables are the same as in model (1). In the above model, βm is the impact of management participation on corporate innovation efficiency, which is used to test Hypothesis 1; β_{ad} is used to measure the impact of venture capital implementation management participation on corporate innovation effects in the context of corporate digital transformation, and is used to test Hypothesis 2.

3.1. Variable description

3.1.1. Measurement of innovation scale and innovation efficiency

Regarding the measurement of innovation scale, most scholars use the number of patent applications and patent grants to measure. Compared with the number of patent applications, some scholars believe that the amount of patent grants can better reflect the level of open and protected innovation of enterprises to a certain extent. At the same time, considering that there is a certain time lag between enterprise patent output and authorization, and some studies believe that the digital transformation of enterprises requires the support of resources such as advanced technology and equipment, capital and talents, enterprises with strong research and development capabilities, the digital transformation of enterprises Therefore, this paper sets the t+1 period of patent authorization to measure the innovation scale of enterprises, in order to avoid the mutual influence between enterprise digital transformation and innovation level and the time-lag relationship between innovation output and factor input. Regarding the measurement of innovation efficiency, this paper uses the ratio between the amount of patent authorization and R&D investment to measure it. The higher the ratio, the more the number of R&D investment per unit amount of enterprise successfully converted into authorized patents, and the higher the innovation efficiency of the enterprise. . Considering the lack of data of R&D personnel, and a certain waiting period is required from the investment in patent R&D to the realization of patent output and finally being authorized, the specific measurement method is: the amount of patent authorization of company i in year t+1 and the amount of patent authorization in company i in year t The logarithm of the R&D investment ratio plus 1.

3.1.2. Manage engagement measures

In the actual operation process of enterprises, there are mainly three ways for venture capital to intervene in start-up enterprises and implement management participation, namely, dispatching directors, dispatching supervisors and dispatching senior executives. Therefore, this paper sets the variable of venture capital's management participation in start-up enterprises as The dummy variable of 0 and 1, if the venture capital institution has assigned directors, supervisors, or executives to start-up companies, define the management participation variable as 1, otherwise it is 0.

3.1.3. Digital transformation measurement

The logarithm of the ratio of the keyword frequency to the total number of words in the company's annual report is used to measure the degree of digital transformation of the company. The specific operation steps are as follows: first, crawl and organize the annual reports of all A-share listed companies on the Shanghai and Shenzhen Stock Exchanges through Python, and extract all the text content to provide a data pool for the subsequent calculation

of the proportion of feature words; then learn from the digitization compiled by Wu Fei et al. Transform the characteristic lexicon, search, match and count the word frequency of the relevant characteristic words in the annual report text of listed companies, and form the final total word frequency after classification and collection; finally build the digitalization of the enterprise according to the ratio of the total word frequency/the total number of words in the text The degree of transformation index, for the convenience of expression, is measured by the logarithmic value of the percentage index in the following text. The higher the index value, the higher the degree of digital transformation of the enterprise.

3.1.4. Control variable measure

The size of the enterprise is measured by the number of employees of the entrepreneurial enterprise; the age of the enterprise is calculated based on the difference between the year of sample observation (the year of the IPO of the entrepreneurial enterprise) and the year of establishment of the enterprise; the proportion of equity of venture capital institutions is based on the proportion of shareholders of the enterprise observed by the sample The share is determined; the age of the venture capital institution is calculated by using the difference between the sample observation year and the establishment year of the venture capital institution; in addition, the cash flow of the enterprise is calculated by selecting the net cash flow generated by the enterprise's operating activities.

3.2. Data source

Regarding the data at the enterprise level, the enterprise scale, enterprise age, return on equity, current ratio, cash flow, asset-liability ratio, total profit, and industry are all from the CSMAR database; the innovation scale data mainly comes from the CSMAR database, and missing data Search and supplement according to the National Bureau of Patent Statistics; the age and shareholding data of venture capital institutions come from the CV_Source database. The management participation of venture capital institutions is derived from the prospectus of the start-up company. If the directors, supervisors or senior management members in the prospectus are from the leading venture capital institution, it is determined that the venture capital institution has management participation in the start-up company. This paper selects Shanghai and Shenzhen A-share listed companies from 2004 to 2020 as the initial research sample, firstly eliminates ST, financial industry, and companies that have been delisted; then eliminates companies with missing R&D expenditure data, and finally determines venture capital through investment case data in the CV_Source database Whether to intervene or not, use the corporate prospectus to check and check, and exclude the investment samples of the venture capital institution established by the enterprise itself; finally select 1274 listed companies with venture capital intervention as the observation sample, and Innoi,t+1 as the explanatory variable The sample observations are 1189.

3.3. Descriptive statistics analysis and T test

Table 1 lists the descriptive statistics of the variables in this paper. Judging from the mean value of the explained variable, the mean value of the innovation output of the enterprise is 1.739; There is a significant difference between innovation scale and innovation efficiency; from the median of the explained variables, the median of innovation scale is 1.792; the median of innovation efficiency is 0.215, and the median value is higher than the average value, indicating that half of the The innovation scale and innovation efficiency of the above-mentioned enterprises are above the average level. In addition, the average value of venture capital's management participation in entrepreneurial enterprises is 0.718, indicating that venture capital has implemented management participation in 71.80% of the sample enterprises. The average value of the digital transformation degree of entrepreneurial enterprises is 0.042, and the higher the value, the higher the degree of digital transformation. The relevant statistics of the control variables are not repeated here, and the values are all within a reasonable range.

At the same time, in order to more intuitively judge the impact of venture capital's management participation on entrepreneurial enterprises on innovation output and innovation efficiency, as well as the moderating role of digital transformation, this paper divides the sample into management participation group and non-management participation group based on whether there is management participation. Manage the participating groups; in addition, based on the average value of the digital transformation of the observed samples, the samples were divided into groups with a high degree of digital transformation and a group with a low degree of digital transformation, and a group test (T test) was performed on the explained variables. The results are shown in Table 2. From the T-test of whether there is management participation, the sample enterprises that implement management participation have significantly higher innovation scale and innovation efficiency than those without management participation. Judging from the group test results of digital transformation, compared with enterprise groups with lower digital transformation, enterprises with higher degree of digital transformation have higher innovation output and innovation efficiency. The results of the group test above provide preliminary support for the research hypothesis verification of this paper.

Table 1: Descriptive statistics of main variables

variable name	variable code	average	standard deviation	median	minimum value	maximum value	Observations
Colu mn A: explained variab les							
t+1 year innovation scale	Inno_pat $_{t+1}$	1.739	1.271	1.792	0	4.883	1189
t+1 year innovation efficiency	Inno_efft+1	0.212	0.152	0.215	0	0.927	1189
Colum n B: Explanatory varia bles							
management participation	Mag	0.718	0.45	1	0	1	1274
digital transformation	Digital	0.042	0.088	0.005	0	0.914	1274
Colu mn C: Control variables							
Enterprise size	Size	6.877	0.967	6.766	5.165	9.819	1274
business age	Firm_Age	2.607	0.369	2.639	1.792	3.401	1274
Return on Assets	Roe	2.62	0.42	2.631	1.105	3.587	1274
cash flow	Liqu	1.674	0.647	1.573	0.654	3.509	1274
Assets and liabilities	Cash	11.209	1.067	11.061	9.444	14.616	1274
current ratio	Leve	3.076	0.655	3.134	1.481	4.251	1274
The total profit	Profit	9.206	0.921	9.074	7.337	12.312	1274
Venture capital age	Vc_age	1.814	0.609	1.946	0	2.89	1274
Share of venture capital equity	Share	1.847	0.8	1.792	0.01	3.638	1274

Table 2: T test of the explained variables

	Is there management involvement			digital transformation		
	No(1)	Yes(2)	(2)-(1)	Low(1)	High(2)	(2)-(1)
innovation scale	1.384	1.884	0.500***	1.598	1.877	0.279***
innovation efficiency	0.172	0.228	0.057***	0.198	0.225	0.027***

Note: Models (1) and (2) are the mean values of the corresponding groups, (2)-(1) is the difference between the two groups, *** p<0.01, ** p<0.05

3. Analysis of empirical results

4.1. Test that venture capital management participates in influencing enterprise innovation

Considering that the sample in this paper is cross-section data, OLS regression is adopted in the empirical process to verify the impact of venture capital implementation management participation on enterprise innovation scale and innovation efficiency. Table 3 reports the test results of management participation on innovation scale and innovation efficiency of enterprises. Columns (2) and (4) are listed as regression control groups without management participation. Columns (3) and (5) respectively show the regression results of management participation on innovation scale and innovation efficiency of t+1 stage. The results show that the regression coefficients of management participation on innovation scale and innovation efficiency are 0.451 and 0.055 respectively, both of which are significant at 1% level, indicating that venture capital management participation positively promotes the improvement of enterprise innovation scale and innovation efficiency. According to the regression results of control variables, there is little difference in the regression coefficient of control variables among all models. Among them, enterprise scale, total profit, age of venture capital, and proportion of venture capital equity are significantly positively correlated with innovation scale and innovation efficiency, which indicates that compared with small enterprises and enterprises with low total profit, The management participation of venture capital with rich experience and relatively high equity can significantly improve the innovation output and efficiency of enterprises with large scale and high total profit. At the same time, cash flow significantly inhibits the innovation scale and innovation efficiency of enterprises. Generally speaking, the method of dispatching directors, appointing directors or dispatching senior executives for enterprise management of venture capital will play an important role in promoting enterprise scale and innovation performance. Hypothesis 1 can be proved.

Table 3: The impact of management participation on the scale and efficiency of innovation Innovation scale innovation efficiency

	Innovation scale		Innovation efficiency	
	$Inno\_pat_{t+1}$	$Inno\_pat_{t+1}$	$Inno\_eff_{t+1}$	$Inno\_eff_{t+1}$
management participation		0.451 ***		0.055***
scale		-5.94		-5.81
enterprise age	0.217***	0.228***	0.023***	0.024***
return on assets	-3.76	-4.01	-3.32	-3.57
cash flow	0.163	0.096	0.027**	0.019
asset-liability ratio	-1.56	-0.92	-2.15	-1.5
current ratio	-0.108	-0.02	-0.003	0.007
total profit	(-0.85)	(-0.16)	(-0.23)	-0.52
Venture capital age	-0.150*	-0.159**	-0.023**	-0.024***

Share of venture capital equity	(-1.94)	(-2.07)	(-2.58)	(-2.71)
constant term	0.236	0.209	-0.002	-0.006
R2 after adjustment	-1.18	-1.07	(-0.09)	(-0.23)
observed value	0.045	0.004	-0.029	-0.034
management participation	-0.22	-0.02	(-1.13)	(-1.35)
scale	0.228**	0.184**	0.018*	0.012
enterprise age	-2.47	-2.01	-1.71	-1.21
return on assets	0.127**	0.118**	0.018**	0.017**
cash flow	-2.12	-1.99	-2.44	-2.32
asset-liability ratio	0.079*	0.067	0.010*	0.009
current ratio	-1.73	-1.48	-1.83	-1.58
total profit	-1.482	-1.243	0.099	0.128
Venture capital age	(-1.31)	(-1.11)	-0.73	-0.96
Share of venture capital equity	0.06	0.085	0.034	0.059
constant term	1189	1189	1189	1189

4.2. Testing the impact of management participation and digital transformation on enterprise innovation

This part continues to verify the effect of enterprise digital transformation regulating venture capital management participation on enterprise innovation, and the regression results are shown in Table 4. In Table 4, columns (2) and (3) show the regression results of innovation scale in t+1 period. The conclusion shows that the influence coefficients of management participation on enterprise innovation scale are significantly positively correlated at the level of 1%. The degree of digital transformation improves the scale of innovation, and the regression coefficient is 1.920, which is significant at 1%. The regression coefficient between the interaction term of management participation and digital transformation degree and innovation scale is 1.312, which is significant at the level of 10%. Columns (4) and (5) provide regression results for innovation performance in t+1 period. The conclusion shows that the impact ratio of management activities on creative performance in t+1 period is significantly positively correlated with 1%, and the ratio range is about 0.054. The standardized regression coefficient of the relationship between digital transformation degree and enterprise innovation efficiency is 0.207, which is obvious at 1% level. The interaction term of enterprise management participation and digital transformation significantly improves enterprise innovation efficiency, and the standardized regression coefficient is 0.382, which is obvious at the level of 1%. The above regression results show that the positive factor in the degree of digital transformation of enterprises is the innovation promotion effect of enterprise management participation, and with the improvement of the degree of digital transformation of enterprises, the promotion effect of enterprise venture capital and actual management participation on the degree of innovation and enterprise creation efficiency is increased, and this hypothesis 2 is verified.

Table 4: Test the effect of management participation and digital transformation on enterprise innovation

	Innovation scale		Innovation scale	
	$Inno\_pat_{t+1}$	$Inno\_pat_{t+1}$	$Inno\_eff_{t+1}$	$Inno\_eff_{t+1}$
management participation	0.449***	0.313***	0.054***	0.039***
Digital transformation	-5.88	-3.83	-5.75	-3.79
Management and participation in the * digital transformation	1.920***	1.344***	0.207***	0.154***

scale	-4.31	-3.51	-3.97	-3.69
enterprise age		1.312*		0.382***
return on assets		-1.99		-3.73
cash flow	0.218***	0.221***	0.023***	0.023***
asset-liability ratio	-3.85	-3.91	-3.42	-3.48
current ratio	0.086	0.078	0.018	0.017
total profit	-0.84	-0.77	-1.43	-1.37
Venture capital age	-0.051	-0.046	0.004	0.005
Share of venture capital equity	(-0.40)	(-0.36)	-0.29	-0.33
constant term	-0.181**	-0.179**	-0.027***	-0.027***
R2 after adjustment	(-2.39)	(-2.39)	(-3.00)	(-3.01)
observed value	0.157	0.187	-0.011	-0.008
management participation	-0.81	-0.97	(-0.45)	(-0.31)
Digital transformation	-0.064	-0.028	-0.041	-0.037
Management and participation in the * digital transformation	(-0.33)	(-0.14)	(-1.64)	(-1.48)
scale	0.210**	0.211**	0.015	0.015
enterprise age	-2.32	-2.35	-1.49	-1.51
return on assets	0.112*	0.113*	0.016**	0.016**
cash flow	-1.9	-1.92	-2.23	-2.26
asset-liability ratio	0.068	0.07	0.009	0.009*
current ratio	-1.51	-1.56	-1.61	-1.66
total profit	-0.854	-0.956	0.17	0.158
Venture capital age	(-0.77)	(-0.86)	-1.27	-1.19
Share of venture capital equity	0.107	0.13	0.184	0.105
constant term	1189	1189	1189	1189

4.3. Robustness test

Based on the above analysis, it can be preliminarily found that management participation contributes to the improvement of enterprise innovation scale and innovation efficiency, and enterprise digital transformation will further strengthen the innovation promotion role of management participation. In order to improve the reliability of the above experimental results, we will continue to carry out robust experiments, mainly through the propensity score matching index (PSM), replacement innovation index, replacement digital transformation industry correlation degree and other methods to further test the above regression conclusions.

4.3.1. PSM matching result

In order to further evaluate the impact of venture capital managers' participation on enterprise innovation, this part will pair innovative enterprises with managers' participation with other enterprises with the same characteristics but lacking managers' participation from various perspectives through PSM matching method, and then calculate the net effect of managers' participation on enterprise innovation. The calculation formula is as follows:

$$\widehat{ATT}=\frac{1}{\sum_i D_i}\sum_{i:D_i=1}(y_i-\widehat{y_{0i}}) \quad (3)$$

In the above equation (5), $\sum$ is the sum of the number of processing groups, yi is the number of observations of enterprises in the processing group, y0i.

It represents the matching value between enterprise i in the same processing group and the control group with the same characteristics, and the ratio between the two ($y_i - y_{0i}$) can well reflect the improvement degree of innovation level caused by the participation of a management group in an enterprise. $\sum_{i:\, Di=1}(y_i - y_{0i})$ indicates the total net utility of the creativity of each firm in the processing group with management participation. This paper also reports the predicted results of kernel matching, as shown in Table 5: After matching, the average utility of the creative scale and creative efficiency of the processing combination is obviously positive at the 1% level, indicating that the creative scale and innovation efficiency of the enterprise with management participation are significantly better than that of the enterprise without management participation. Specifically, compared with enterprises without management participation, the innovation scale pair value of enterprises with management participation is 0.450 higher, indicating that such enterprises authorize nearly 2 more patents on average. From the matching results of innovation efficiency, the innovation efficiency of the treatment group is 0.053 higher than that of the control group. In summary, the regression results of PSM show that management participation has a positive promoting effect on both enterprise innovation scale and innovation efficiency, which verifies the above hypothesis 1.

Table 5: Shows the average processing effect of enterprises with management participation after matching

ATT	Processing group	control group	Differential value	standard deviation	T statistical quantity
Innovation scale	1.875	1.425	0.450***	0.081	5.58
Innovation efficiency	0.228	0.175	0.053 ***	0.01	5.35

Note: In order to ensure the robustness of matching results, this paper continued to use one-to-many matching and self-help method, and found that the size and significance of the average treatment effect remained basically unchanged.

As can be seen from the standardized error curve after matching (FIG. 1) and the common value range diagram of propensity score (FIG. 2), except for leve and asset liquidity ratio, the standardization deviation of most control variables decreased after matching, and the value range of these samples was also within the common value range, and only a few samples were lost. The calculated group lost about 15 samples, while the control group lost seven. In addition, from the distribution diagram of enterprises' propensity score in the matching (FIG. 3 and 4), the vertical axis represents probability density and the horizontal axis represents propensity score. Enterprises with management participation are represented by solid lines, while enterprises without management participation are represented by dashed lines. However, after kernel matching (FIG. 4), people can intuitively see that the ratio of propensity score values of the two samples is basically similar, indicating that the score gap between the two samples can be more reasonably adjusted by using propensity score matching, and the matching result is also more ideal.

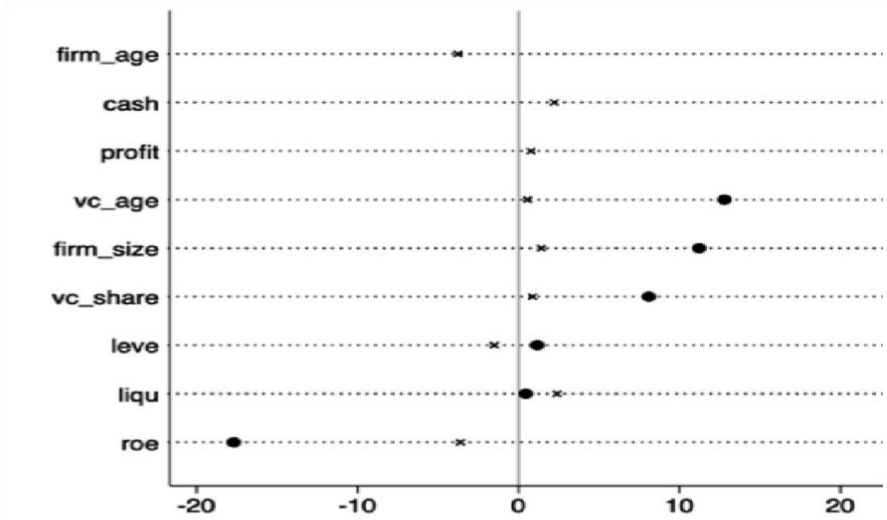

Figure 1: Standardization deviation of each variable

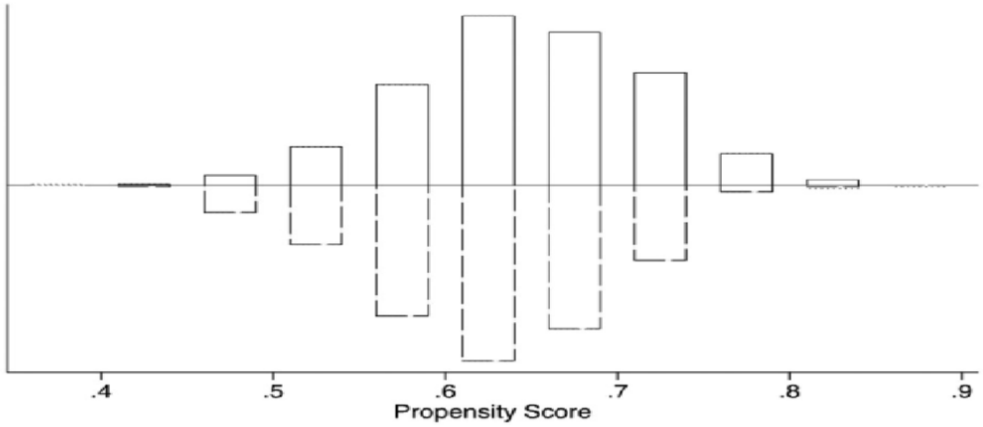

Figure 2: Common value range of propensity score

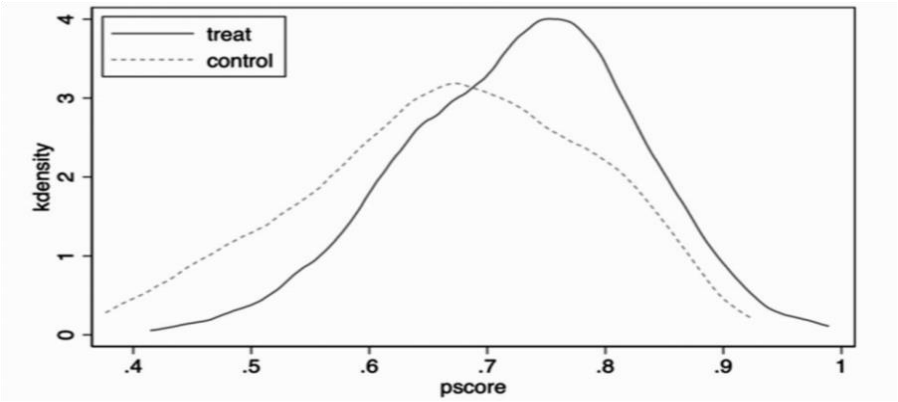

Figure 3: Distribution of score probability density before matching

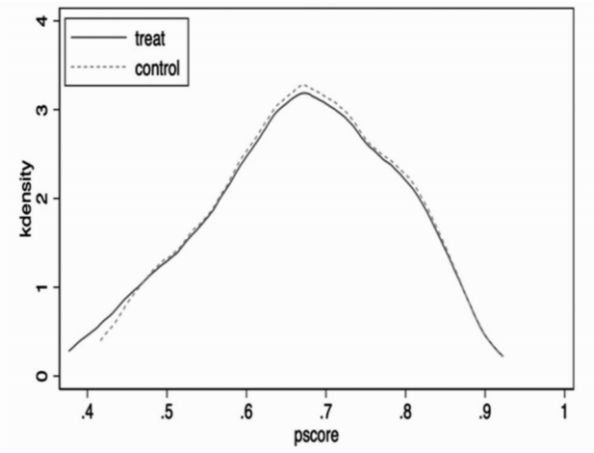

Figure 4: Distribution of score probability density after matching

4. Conclusion and Prospect

Venture capital plays a pivotal role in enterprise innovation. This article takes the data of 1,274 enterprises with venture capital intervention in China's Shanghai and Shenzhen A-shares from 2004 to 2020 as a sample, and systematically analyses the impact of venture capital management participation on enterprise innovation by taking the digital transformation of enterprises as a regulatory variable. The research conclusion shows that: First, venture capital institutions can effectively help enterprises improve innovation efficiency by participating in the daily management of start-up enterprises through resident executives and supervisors, and provide sufficient strategic resources, appropriate consulting services, and all-round supervision and control for enterprises in the process of achieving their goals. Second, through their own digital transformation, start-ups have strengthened their cooperation ties with venture capital institutions, which not only reduces the communication and operating costs of the two sides, but also improves the quality of information exchange and the spillover effect of R&D innovation resources, and promotes enterprise innovation. Third, the effect of resident compound management talents with both financial and technical background in promoting enterprise innovation is significantly higher than that of financial or technical managers. The above conclusions show that the composite management participants combine the R&D acumen of technical executives and the operational prudence of financial executives, which can better provide enterprises with accurate value-added services and moderate supervision and control, so as to improve the innovation output and innovation efficiency of enterprises.

The research conclusions of this article will have a certain guiding significance for the implementation of venture capital and enterprise innovation practice, regional high-quality development, and innovation-driven development strategy, which are manifested in the following three aspects:

First, based on the investment strategy of venture capital institutions, first of all, venture capital needs to adjust its investment concept, enhance its own post-investment management services, and realise the transformation from "capital operator" to "financial service provider"; realise the transformation from rapid withdrawal capital to long-term planning capital after IPO, which has great growth. Space's high-tech enterprises plan long-term counselling to obtain long-term benefits. Secondly, venture capital institutions should use digital networks and platforms to evaluate the qualifications and innovation capabilities of start-ups. At the same time, extensive search information and reasonable analysis of industry trends are conducive to the smooth development of enterprise innovation. Thirdly, venture capital institutions are conducive to the enrichment of enterprise investment experience and the improvement of the reputation of the industry, as well as the enrichment and specialisation of their own organisational structure and control system.

Second, based on the practice of enterprise innovation, start-up enterprises need to implement the concept of high-quality development and reasonable strategic plan, focus on long-term sustainable development, focus on the research and development and innovation of the main business, and gather the unique brand competitiveness of the enterprise itself. At the same time, using scientific and technological innovation and digital transformation, start-up enterprises should keep up with the trend of the times, combine emerging technologies with their own industrial chain, organisational structure and control systems, and fully integrate, allocate and use the industry's advanced technology, social capital, large market, management experience and other resource elements to drive the economic benefits of enterprises. Long.

Third, based on the regional innovation and development strategy, the first is to actively build various digital platforms to strengthen the cooperation ties with venture capital institutions and realise the coordinated development of financial services and scientific and technological innovation. The second is to establish and improve the digital docking platform for investment and innovation projects, narrow the gap of information asymmetry between investors and investors, avoid the risk of illegal regulations of enterprises, and avoid the short-sighted behaviour of ignoring long-term returns. The third is to strengthen the protection of intellectual property rights of enterprises by local governments, and fully stimulate the willingness of venture capital and start-ups to continue to develop innovative products and obtain innovative returns.

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