Research on the Impact of PSM-based Venture Capital on Enterprise Technology Innovation Performance

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Abstract

Venture capital investment (VC) is one of the most effective ways for startups to obtain funding support. Venture capital investment not only provides financial support for these enterprises, but also provides value-added support for projects with growth potential. This article analyzes the impact of venture capital on corporate performance growth and innovation output using propensity matching scores.

Keywords

Venture capital; Technological innovation performance; PSM model.

1. Introduction

In recent years, venture capital has developed rapidly in China. Venture capital has played an increasingly important role in the technological innovation and performance growth of Chinese enterprises. Well-known Internet giants such as BAT have obtained venture capital, and the constant emergence of sky-high financing has also caused the market to boil, and the valuation of startups by venture capital institutions has become a focus of attention. As the main target of venture capital, startup companies are often in the early stages of development. They have novel business models, no stable profits, high development uncertainty, and lack of a complete information disclosure mechanism. This makes venture capital institutions more severe when they value them. Of information asymmetry. Then, whether China's venture capital can promote the performance growth of venture companies under the existing environment, which is particularly important for the development of China's venture capital in the future.

Chemmanur et al.[1] Analyzed the process of venture capital entering the enterprise screening process and monitoring process after entering the enterprise, and found that venture capital would choose a company with higher operating efficiency and would improve the operating efficiency of the enterprise. Other related research indicates that venture capital promotes the improvement of corporate innovation performance, venture capital value-added services can significantly improve corporate performance, and supervision and control and investment in research and development have no significant effect on corporate performance[2-4].

2. Research design

2.1 Model Building for Preference Score Matching (PSM)

At present, most related researches start from the perspective of investment companies and use multiple linear regression methods for analysis and verification, ignoring the potential endogenous choice between venture capital companies and listed companies. Specifically, whether the venture capital firm selected by venture capital itself has high innovation performance.

In this article, we have selected the total return on assets (*roa*), the return on net assets (*roe*), and the ratio of main operations (*mbr*) to characterize whether a company has a venture capital participation that affects the innovation performance of the company. Quantitatively distinguish the comparison of non-risk investment participation, and define $Y^{(1)}$ is the indicator variable of enterprises with risk

investment participation, and $Y^{(0)}$ is the indicator variable of enterprises without risk investment participation. Let *ATT* be the average impact, then:

$$ATT = E\left[Y^{(1)} - Y^{(0)} | VC = 1\right] = E\left[Y^{(1)} | VC = 1\right] - E\left[Y^{(0)} | VC = 1\right] \quad (1)$$

Based on the index variables used to characterize corporate performance, *ATT* refers to the difference in expectations of *roa*, *roe*, and *ope*. If the qualifications of venture-capital-equity companies and those without venture-capital-equity companies are not related, they can be directly compared.

Next, we need to determine which company characteristics affect the venture capital. We analyze the development of the company and the profitability of the company, and set up an experimental group and a control group to match the sample companies. Suppose there are m variables that affect the choice of corporate venture capital, and set it to a vector *X*, then $X = (X_1, X_2, \ldots X_m)$, then if other conditions are the same (that is, two companies have the same variable *X*), if The performance indicators (dependent variables) have significant differences, then this difference is only related to the control variable (whether there is a risk investment capital injection), which is called the independence assumption.

The independence assumption can be expressed as:

$$E\left[Y^{(0)} | VC = 1,\ X = x\right] = E\left[Y^{(0)} | VC = 0,\ X = x\right] \quad (2)$$

The VC = 1 indicates that venture capital funds have entered the enterprise. Assuming it is established, the average impact can be expressed as:

$$ATT = E\left[Y^{(1)} | VC = 1,\ X = x\right] - E\left[Y^{(0)} | VC = 0,\ X = x\right] \quad (3)$$

Due to the existence of multiple factors that influence venture capital participation (*X* is a multi-dimensional vector), it is difficult to find the exact same variable *X* when matching the experimental and control companies. If there is a deducible function b ( ) that can reduce the *X* dimension to 1, then one-to-one matching between the experimental group and the control group can be achieved using nearest neighbor matching, and the conditional probability of the venture capital institution participating in the enterprise's investment can be found, Estimate the average processing effect according to the following formula:

$$ATT = E\left[Y^{(1)} | VC = 1,\ b(X) = b(x)\right] - E\left[Y^{(0)} | VC = 0,\ b(X) = b(x)\right] \quad (4)$$

According to the sample characteristics of listed companies, we divided them into experimental groups (with risky investments) and control groups (without risky investments) based on whether or not they have invested in stocks. After using the tendency score matching method to allocate sample companies, whether the venture capital is involved in listed companies is changed from a non-random problem to a random problem. The performance difference between the two groups of companies after the tendency score matching is the venture capital entry Impact on corporate performance.

The company's performance and R & D activities are the two major areas we focused on in this study. According to the characteristics of the company's own development and profitability, we match venture-backed companies with non-venture-backed companies to reduce potential selection problems. Then, we analyze the role of venture capital stocks by comparing the performance of the sampled companies and matching companies. In the calculation of the average treatment effect *ATT*, in order to overcome the uneven distribution of the number of samples in the experimental group and the control group and avoid affecting the final matching score, this article refers to the method of Rosenbaum & Rubin[5] to obtain the basic steps are as follows: (1) Repeatably randomly select m observations from the original sample and call it an empirical sample; (2) Use the matching method described above to calculate the average processing effect *ATT* of the empirical sample; (3) apply The first and second steps are repeated *K* times (*K* is taken as 500 in this paper) to obtain *K* empirical statistics of the average incentive effect *ATT*, that is, ATT_1, ATT_2, ..., ATT_X; (4) calculate ATT_1, ATT_2, …, The standard deviation of ATT_X, you can get the standard deviation of the *ATT* statistics of the original sample.

2.2 Data Sources

According to the characteristics of the majority of venture capital investments in high-growth small and medium-sized enterprises, this article selects the GEM listed companies of the Social Exchange as the research object, and collects and sorts 754 companies listed on the GEM between 2009 and 2018 as research samples. It mainly comes from the annual reports of listed companies approved by Guotai'an Database and the Shenzhen Stock Exchange website. The data not found is collected manually.

By extracting the information of the top ten shareholders of the above-mentioned enterprises from 2016 to 2018 from the Guotai'an database, the words "venture investment", "venture investment", "innovation investment" appear in the name of the shareholder or the shareholders' business scope during the period 2016-2018 "Investment in equity holding business", "equity investment", "venture investment", "investment management", "investment in high-tech projects and enterprises" and other keywords, the company is considered to be invested by venture capital.

2.3 Index selection and data description

With regard to the selection of variables, referring to previous studies, independent variables were selected for the three indicators of risk investment, joint venture investment and individual venture investment. The specific variable names and explanations are shown in Table 1.

Table 1 Variable description and index description

Category		Name	Symbol	Description
Dependent variable		Return on total assets	roa	Net profit / Average total assets
		Return on equity	roe	Profit after tax / Owners' equity
		Main business ratio	mbr	Main business profit / total profit
Matching variables	Enterprise development	Year	year	Years from establishment to listing
		Company insize	lnsize	Logarithm of total assets of the enterprise
		Staff size	lnems	Natural logarithm of total number of employees at the end of the period
		Area	area	Set 1-7 virtual variables according to headquarters location
	Enterprise profitability	Total R & D expenditure as a percentage of operating income	roi	Total R & D expenditure / operating income
		Asset liability ratio	alr	Total Ending Liabilities / Total Ending Assets
		Total asset turnover	tat	Net sales revenue at the end of the period / average total assets at the end of the period
		net profit margin	npm	Net profit / net sales revenue
		Year-on-year growth rate of operating revenue	gro	(Current operating income-previous operating income) / last operating income
		Year-on-year growth rate of net profit	grn	(Net profit for the current period-Net profit for the previous period) / Net profit for the previous period
		Current ratio	cr	Total current assets / total current liabilities
		Quick ratio	qr	Quick assets / current liabilities
Independent variable		Whether there is venture capital	vc	Whether the top ten shareholders of the company have venture capital. If there is a venture capital, the VC is assigned a value of 1. If not, it is assigned a value of 0.
		Joint venture capital	jvc	Does the top ten shareholders of the company have two or more venture capital
		Individual venture capital	ivc	Does the top ten shareholders at the time of the company's listing contain 1 venture capital

3. Empirical analysis

3.1 Descriptive statistical analysis

Table 2 Performance variable description statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
roa	2,030	7.920398	7.762878	0.1218	75.5752
roe	2,030	8.989608	12.15418	0.4107	86.4897
mbr	2,030	80.51297	54.05698	0.5762	49.936

The descriptive statistical analysis of the indicators that characterize corporate performance in this article is shown in Table 2.

The descriptive statistical analysis of the tendency score matching variable indicators in this paper is shown in Table 3.

Table 3 Statistical description of tendency score variables

Variable	Obs	Mean	Std. Dev.	Min	Max
roi	2,030	7.236707	6.512386	.02	.7508
alr	2,030	30.75808	16.7213	.054	.8932
tat	2,030	.5554578	.5027348	.0201	2.9725
npm	2,030	10.05322	14.02429	.0602	.6398
gro	2,030	34.73649	18.3779	.0644	269.92
grn	2,030	48.98451	7.219	.09	.43
year	2,030	10.63768	4.583591	4	39
lnsize	2,030	11.97927	.890529	8.986	15.334
lnems	2,030	6.899178	.8745779	3.2581	10.055
cr	2,030	3.880352	5.684748	.3813	2.0001
qr	2,030	3.348045	5.395766	.242	1.603
area	2,030	3.400966	1.264299	1	7

3.2 Empirical analysis of propensity score matching

This article selects the total R & D expenditure as a percentage of operating income (*roi*), asset-liability ratio (*alr*), total asset turnover (*tat*), net sales margin (*npm*), year-on-year growth rate of operating income (*gro*), and net profit growth rate (*grn*), company duration (*year*), company size (*lnsize*), employee size (*lnems*), current ratio (*cr*), quick ratio (*qr*), and area (*area*) are used to logit regression model The model is as follows:

$$\text{Logit}(v_c = 1|z)_i = \emptyset(\beta_0 + \beta_1 \text{roi}_i + \beta_2 alr_i + \beta_3 tat_i + \beta_4 npm_i + \beta_5 gro_i + \beta_6 grn_i + \beta_7 year_i + \beta_8 lnsize_i + \beta_9 lnems_i + \beta_{10} cr_i + \beta_{11} qr_i + \beta_{12} cr_i)$$

First, through the establishment of the logit model, we can determine which variables are the main variables that affect whether a venture capitalist chooses a company and decides to inject capital into it[6]. In order to exclude the effect of the lagging period of the explanatory variable on the current period, we chose to use the lagging period of the indicator to perform logit regression, because the lagging term can exclude the current period of influence to a certain extent, that is, Endogenous is excluded[7]. The lag period of the explanatory variable must be related to the current period of the explanatory variable, but since the unobservable variable (perturbation term) is determined, the lag period of the independent variable is not related to the current disturbance term, so the lag period is a perfect instrument variable of the current period[8]; Second, by scoring the tendency of the above index variables, the probability of venture capital involvement in the company and its financial support is obtained; Third, through the tendency score result (*ATT*), the sample companies were matched according to the score values to the companies with similar ATT score values (control group),

In this way, the endogenous problem of the relationship between sample selection bias and venture capital and corporate innovation performance is avoided[9]. Logit model regression results are shown in Table 4.

From the logit regression results in Table 4, the total R & D expenditure as a percentage of operating income, current ratio, and quick ratio have a significant negative impact on venture capital, asset-liability ratio, total asset turnover ratio, net sales margin, year-on-year growth rate of operating income, companies The existence period, company size, staff size have a significant positive impact on venture capital, the year-on-year growth rate of net profit has limited impact on venture capital, and the impact of the location of the company on whether or not the venture capital is injected is not significant.

Table 4 Logit model regression results

vc	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
roi	-.0044334	.0013523	-3.28	0.001	-.0070854	-.0017814
alr	.0011041	.000513	2.15	0.032	.0000979	.0021103
tat	.0343183	.0168324	2.04	0.042	.0013077	.0673289
npm	.0003954	.0002063	1.92	0.055	0.00	.0007999
gro	.0021062	.0015694	1.34	0.180	-.0009698	.0051822
grn	0.00	.0000149	0.55	0.586	-.0000212	.0000375
year	.0138076	.0137081	1.01	0.314	-.0130598	.040675
lnsize	.0348814	.0095162	3.67	0.000	.0162189	.0535439
lnems	.045525	.0096792	4.70	0.000	.0265427	.0645072
cr	-.006415	.0014914	-4.30	0.000	-.0093399	-.0034901
qr	-.0063066	.0015727	-4.01	0.000	-.0093908	-.0032224
area	-.0017451	.0067507	-0.26	0.796	-.0149842	.0114939
cons	-.9795012	1.112366	-0.88	0.379	-3.159698	1.200696

Based on the analysis of the results of logit regression on the indicators above, we have screened out the various indicator variables that have a significant impact on the innovation performance of the enterprise. Next, based on the screening results of the logit model, we select three dependent variables that represent the innovation performance of the enterprise, which are the total Return on assets (*roi*), return on net assets (*roe*), and main business ratio (mbr). According to the characteristics of the data, the close matching method is selected to perform the tendency matching score. The results of the tendency matching score are shown in Table 5 below.

Table 5 Matching results of venture capital and innovation performance propensity scores

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
roa	Unmatched	8.17674528	8.75103537	-0.57429009	.447652394	-3.18
	ATT	8.16748191	6.84922188	1.31826003	.640453415	2.06
roe	Unmatched	9.47017364	9.7974364	-0.32726276	.700119626	-3.82
	ATT	9.45819794	7.30136482	2.15683312	1.18055862	1.83
mbr	Unmatched	80.2897555	81.5312004	-1.24144496	3.12490171	-0.40
	ATT	80.4698238	80.3650316	0.1047922	3.44117136	1.22

In the results of the matching of the propensity score of venture capital and enterprise innovation performance in the table above, Unmatched represents the comparison of the innovation performance of companies with venture capital background and risk-free investment background before propensity score matching, and *ATT* is the matched enterprise innovation performance score. Treated is the

experimental group of companies (with VC injection), Controls is the control group of companies (without VC injection), Difference is the average difference in innovation performance between the experimental group and the control group of companies, SE is the standard error, and T-stat is the T statistic. When 1.64<|T|<1.96, it means that the difference in business performance is significant at the level of 10%, and when 1.96<|T|<2.576 is at the 5% level Significant, when |T|>2.576 is significant at the 1% level. According to the matching results in the table, in terms of return on total assets (*roa*), before the propensity score matches, the companies with venture capital injection (experimental group) are smaller than those without risk investment (control group). The error is 0.447, which is significant at the 1% level; After matching, companies with venture capital injection (experimental group) have a greater return on total assets than those without risk investment, with an average difference of 1.3183 and standard error of 0.640, which is significant at the level of 5%. In terms of return on net assets (*roe*), the companies with venture capital injection before the match (experimental group) were lower than those without risk investment (control group), with an average difference of -0.327, standard error of 0.7001, and Significant at level; After matching, the enterprises with venture capital injection (experimental group) were higher than those without risk investment (control group), with an average difference of 2.157 and standard error of 1.181, which was significant at the level of 10%. In terms of main business ratio (*mbr*), the companies with venture capital injection before the match (experimental group) were lower than those without risk investment (control group), with an average difference of -1.241 and standard error of 3.125. The results were not significant; After matching, the companies with venture capital injection (experimental group) were higher than those without risk investment (control group), with an average difference of 0.105 and standard error of 3.441, and the results were not significant. This shows that the main business ratio has not significantly improved the corporate performance before and after the venture capital injection.

In the above results, we obtained the propensity score and the final matching result. Next, we need to further verify the two assumptions of propensity score matching, namely the common support frame assumption and the balance assumption, see Table 6.

Table 6 Common support hypothesis test results

psmatch2:	psmatch2: Common		
Treatment	support		
assignment	Off support	On support	Total
Untreated	0	365	365
Treated	23	1,642	1,665
Total	23	2,007	2,030

It can be seen from Table 6 that there are a total of 2007 companies in the sample company that meet the common support assumptions, of which there are 1,642 in the experimental group and 365 in the control group. The results of the majority of companies that meet the common support assumptions. Therefore, it shows that the matching result of the propensity score is in line with the common support hypothesis.

The Figure 1 above shows the result of the tendency matching score. From the figure, it can be seen that the experimental group and the control group are matched according to the tendency matching score. The red bar graph represents the experimental group, the blue bar graph represents the control group, and the experimental group in the figure. And the control group is more evenly distributed, the number is basically the same, see Table 7.

In the balance hypothesis test results in the Table 7, U represents the difference between the experimental group and the control group in terms of corporate innovation performance before the propensity score matches; M is the difference between the experimental group and the control group

in terms of corporate innovation performance after propensity score matching. From the results in the table, it can be seen that the P values are greater than 0.05 after matching, and there is no significant difference in the matching variables between the experimental group and the control group, which can confirm that the equilibrium assumption is established. In summary, the conditions of the common support hypothesis and the balance hypothesis can be verified, so the matching result of the propensity score is valid.

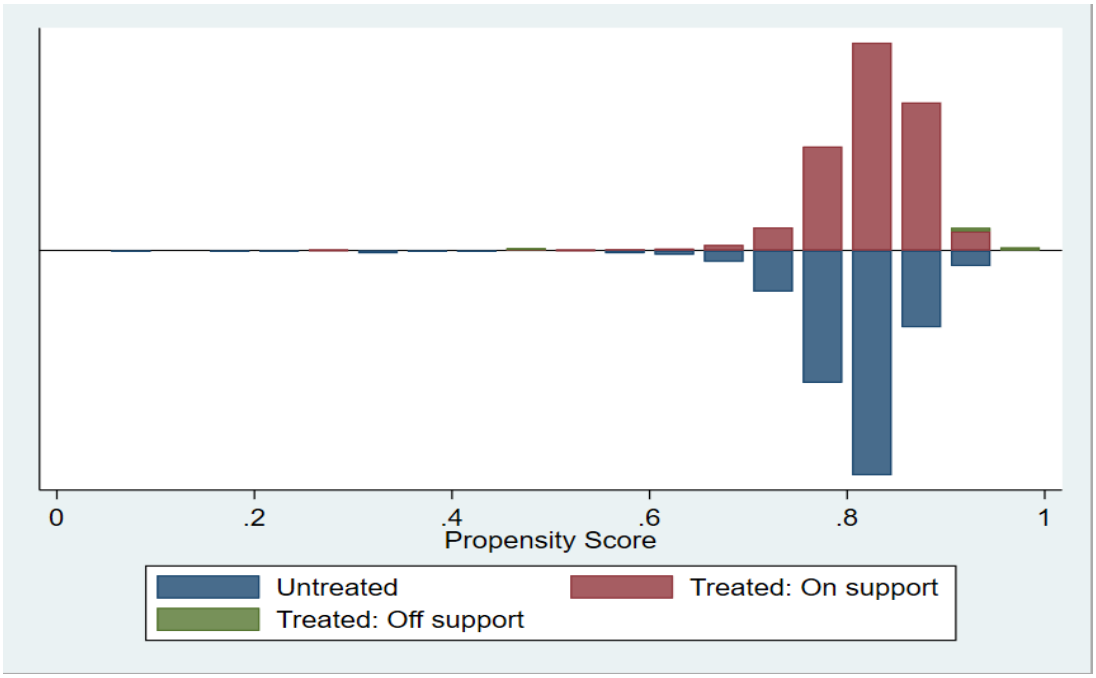

Figure 1 Matching results

Table 7 Balanced hypothesis test results

	Unmatched	Mean		%reduct		t-test		V(T)/ V(C)
Variable	Matched	Treated	Control	%bias	|bias|	t	p>|t|	
roi	U	6.8883	8.0774	-16.8		-3.28	0.001	0.50*
	M	6.937	7.0275	-1.3	92.4	-0.45	0.650	1.04
alr	U	31.074	29.01	12.3		2.15	0.032	0.93
	M	30.809	30.968	-0.9	92.3	-0.28	0.777	1.04
tat	U	.57097	.51136	13.8		2.04	0.042	3.78*
	M	.54424	.54245	0.4	97.0	0.19	0.851	1.11*
npm	U	11.065	6.4922	10.1		1.92	0.055	0.59*
	M	11.071	9.4198	3.7	63.9	1.49	0.135	3.27*
gro	U	37.522	21.786	9.9		1.36	0.174	29.24*
	M	27.24	27.599	-0.2	97.7	-0.26	0.795	0.76*
grn	U	32.543	14.557	2.3		0.55	0.586	0.17*
	M	28.278	37.671	-1.2	47.8	-0.38	0.702	0.19*
year	U	10.661	10.562	2.3		0.38	0.707	1.41*
	M	10.688	10.934	-4.7	98.9	-1.63	0.104	1.40*
lnsize	U	12.005	11.816	21.7		3.67	0.000	1.17*
	M	11.991	12.003	-1.4	93.7	-0.39	0.696	1.13*
lnems	U	6.9419	6.7049	27.3		4.70	0.000	1.02
	M	6.9296	6.9592	-3.4	87.5	-0.97	0.331	0.95
cr	U	3.6124	5.0217	-18.4		-4.30	0.000	0.17*

	M	3.6299	3.4574	2.2	87.8	1.28	0.201	1.34*
qr	U	3.1112	4.3587	-17.2		-4.01	0.000	0.18*
	M	3.1273	2.9427	2.6	85.2	1.44	0.151	1.41*
area	U	3.3784	3.3973	-1.5		-0.26	0.796	1.08
	M	3.3794	3.3606	1.5	36.8	0.43	0.665	1.11*

In the balance hypothesis test results in the Table 7, U represents the difference between the experimental group and the control group in terms of corporate innovation performance before the propensity score matches; M is the difference between the experimental group and the control group in terms of corporate innovation performance after propensity score matching. From the results in the table, it can be seen that the P values are greater than 0.05 after matching, and there is no significant difference in the matching variables between the experimental group and the control group, which can confirm that the equilibrium assumption is established. In summary, the conditions of the common support hypothesis and the balance hypothesis can be verified, so the matching result of the propensity score is valid.

4. Conclusion and suggestion

This article selected a total of 754 listed companies listed on GEM between 2009 and 2018 as the research sample, and used the propensity score matching method (PSM) to solve the potential endogenous choice between venture capital and listed companies. Based on whether or not there is a venture capital institution's equity participation, the sample companies are divided into venture capital institution equity enterprises (experimental group) and non-risk investment institution equity enterprises (control group). The same situation is found for each venture capital enterprise Or similar companies, compare the experimental group with the control group. This article explores the impact of venture capital on corporate innovation performance from the perspective of corporate development and profitability. The study found that from the perspective of the development of the company itself, the duration of the company, the size of the company, and the size of the employees all played a certain positive role in attracting venture capital injection into the company, and the impact of the region where the company was located on whether the venture capital injection could be obtained Limited degree; From the perspective of corporate profitability, companies with a higher ratio of total R & D expenditures to operating income have a certain negative role in attracting venture capital; Enterprises with high liquidity ratios and quick ratios will have a certain negative impact when venture capital chooses companies for capital injection. In contrast, venture capital companies prefer the asset-liability ratio, total asset turnover ratio, net sales margin, and operating income For companies with a high year-on-year growth rate, it is more likely that they will choose ventures with high indicators; The year-on-year growth rate of net profit has a limited effect on the capital injection to attract venture capital.

In order to more effectively play the role of venture capital in promoting corporate innovation and promote the transformation and upgrading of China's industrial structure, this article proposes the following points based on the research above: First, establish and improve the market mechanism for venture capital, strengthen the construction of laws and regulations related to the capital market, and curb the “investment by name” motivation of venture capital, and play the role of certification, supervision and market for venture capital. Second, breakthrough innovation is the foundation to promote the improvement of the technological level of Chinese enterprises and the upgrading of the industrial structure. It is necessary to establish a mechanism to guide and encourage the venture capital stage to move forward and support entrepreneurial enterprises' breakthrough innovation. Third, give play to the guiding role of venture capital guidance funds, strengthen the diversification of venture capital entities, diversification of investment methods, and leverage the complementary advantages of venture capital resources.

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