

# Market Competition, R&D Investment and Innovation Output: Conditional Process Analysis Based on the Moderating Effect of Venture Capital

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**Abstract.** Small and medium-sized enterprises are the main carriers to promote national economic growth and employment, and these enterprises' innovation ability is closely related to the country's innovation strategy. As "High-energy Capital", venture capital is an important means to promote innovation output performance and increase R&D input of these enterprises. This research adopts the "Conditional process model" proposed by Hayes to replace the traditional mediating model, and according to the regulation of venture capital, the study analyzes this conditional process of small and medium-sized scientific and technological enterprises and explores the nexus between market competition and the innovation output. Empirical research shows that the degree of market competition restrains the creative production of enterprises through the balancing effect of R&D spending, and the venture capital can adjust every path in the conditional process model to advance innovation output of enterprises. The conclusions provide enlightenments for the decision-making of these enterprises, and facilitate local governments to formulate reasonable innovation policies according to market competition.

**Keywords:** Market competition; R&D investment; innovation output; conditional process model.

## 1. Introduction

The implementation of innovation strategy is essential for scientific and technological enterprises, especially for those enterprises with small business scale and few employees. The development of many high-tech industries at home and abroad and the practice of regional economic development fully show that enterprises with small business scale and few employees not only provide an important foundation for promoting the development of traditional industries and regional economy, but also play an important role in the development of Independent innovation value and the formation of advanced innovation systems in various countries and regions.

Scientific and technological enterprises are an important source of technological innovation and are at the core of in China's innovation strategy. In general, small and medium-sized science and technology companies are numerous and face more intense market competition. Therefore, an in-depth study on the influencing factors of innovation output of these scientific and technological enterprises will help to enhance the national industrial strength, and meanwhile improve the overall competitive advantage of China's innovation.

## 2. Theoretical Analysis and Literature Review

Market competition among enterprises can be seen as resource allocation behavior affecting the coordinated development of regional economy, and the cooperation and learning behavior of various subjects will also be affected by market competition [1, 2]. R&D investment and venture capital are the business strategy and financing mode of the enterprise, respectively. As internal factors, they affect the innovation output of the enterprise [3, 4]. At present, researches on the nexus between market competition and innovation output of small companies are seldom conducted, and most of them are conducted from different angles by taking listed companies on the main board as samples. For ownership structure, supply chain relationship and customer relationship, and draw the conclusion that the degree of market competition can inhibit the effectiveness of enterprise

innovations. The more competitive the market is, the more advantageous to the improvement of enterprise innovation intensity and independent innovation ability [5].

Venture capital, as “high-energy capital”, is a necessary means to alleviate the difficulties of starting a business, financing and development, an effective way to expand direct financing and promote the development and prosperous of the substantial economy. Venture capital is vital important for enhancing the technological progress of the whole nation and promoting the optimization of industrial structure [6]. Venture capital will promote technological innovation in China's market environment [7], so China has also been increasing its guiding role in venture capital [8]. From the perspective of regional innovation, it vital important to promote the transformation efficiency and exclusive quality of regional science and technology [9]. Under the conditions of foreign developed capital markets, venture capital is beneficial to the scientific innovation output of manufacturing industry. Current studies mainly focus on the nexus between venture capital and innovation output, and these researches tend to carry out at the national, regional or industry level, and it is rare to consider those scientific and technological enterprises with small business scale and few employees. In addition, most studies only control the relevant variables, and do not further classify the scale and region of enterprises.

### 3. Research Method

This study takes small and medium-sized technological and scientific enterprises as research objects. Due to the availability of data, the most representative GEM Company (GEM) and the companies of the above size are listed as the research samples. The study adopts the “conditional process model” proposed by Hayes et al. to replace the traditional regulated intermediary model [10].

#### 3.1 Sample and Data

The unbalanced panel data and GEM listed technology companies during the period of 2007-2019 are taken as the research samples, and the related samples and data are sorted out as follows: (1) The technology companies listed on small and medium-sized board and startup board are selected, and their main businesses are electronic information, optoelectronics, biomedicine, new materials, aerospace, new energy and high technology. Listed enterprises in technical fields such as energy efficiency and energy conservation; (2) Eliminate the samples of companies with missing key data such as main business income and patent number; (3) Classify the industries of listed companies in 2012. “Guidelines for Industry Classification of Listed Companies” for classification and collation, which is used to inquire and calculate the Herfindahl index; (4) Referring to the classification methods of Venture Capital in the existing research [11]. According to the basic information which is ranked on the top ten shareholders enterprises, the enterprises with keywords such as venture capital in the list of top 10 most influential shareholders are screened out, and finally an unbalanced panel data set with 744 observations is formed for judging venture capital holdings. The financial data mainly come from CSMAR database, China Economic and Trade Database and official website of National Bureau of Statistics.

#### 3.2 Variable Definition

Table 1 shows the symbols and definitions of all variables of this study.

**Table 1.** Variable definition

Variable name	Symbol	Variable type	Definition and unit
Degree of market competition	MC	Explanatory variable	Herfindahl index of market power. Absolute value of logarithm
Innovation output	Patent	Explained variable	Application of the enterprise in the current year as of the reporting period. Total number of patents
R&D investment	RD ratio	mediator variable	R&D investment accounts for main business income. Ratio
Risk investment	VCSH	Regulated variable	Among the top ten shareholders, venture capital holds. Total share of shares
Scale	Size	Control variable	The Natural Logarithm of Enterprise Sales. Revenue
Enterprise age	Year	Control variable	From the establishment of the enterprise to the closing date of the statement. Year
Profitability	ROTE	Control variable	Total profit and total assets. Specific value
Trading on equity	LEV	Control variable	Total liabilities and total assets. Specific value
Asset structure	RTA	Control variable	Net tangible assets and net assets Ratio
Region	AREA	Control variable	The eastern and central regions are set to virtual change from 0 to 1. The western region is 0

## 4. Analysis and Empirical Results

### 4.1 The Effect of Market Competition on Innovation Output

According to regression results in Table 2, it is concluded that the effect of market competition on innovation output is inconspicuous, and further in-depth analysis is made through sample classification. In this study, the samples are grouped into three regions, and based on the enterprises' scale, the samples are divided into larger enterprises (the size value is greater than the average value of all samples) and smaller enterprises (the size value is less than all samples). The market competition degree has no significant effect on innovation output. This analysis result may be due to the fact that the samples selected in this paper are small. The results show that the degree of market competition will not have a direct impact on small- to medium-sized technological and scientific businesses' capacity for entrepreneurship without R&D input.

**Table 2.** Regression results of market competition degree on innovation output

Variable	Full sample	Enterprises in eastern and central regions	Western enterprises	Large-scale enterprises	Smaller enterprises
MC	-0.003	0.015	-0.075	0.04	0.021
Year	0.059*	0.08**	0.003	0.037	0.078*
Size	0.24***	0.204***	0.391***	0.32***	-0.09*
RTA	-0.062*	-0.019	-0.24***	-0.064	-0.022
LEV	0.175***	0.195***	0.07	0.127**	0.276***
ROYE	0.014	0.024	-0.039	-0.007	0.064
AREA	0.004			-0.038	0.064
R2	0.119	0.113	0.183	0.132	0.001
F	15.365***	13.979***	5.802***	8.355***	5.323***

Note: \*\* \*, \*\* and \* are respectively at the level of 1%, 5% and 10%.

#### 4.2 The Intermediary Influence of R&D Investment

Simple mediation model in Hayes conditional process model is used to test the mediation impact of R&D investment on marketplace bidding and competition and innovation output. The controlled variables in the inspection process are the age, scale, asset structure, profitability and region of the enterprise. The coefficient and results are shown in Table 3.

After controlling related variables, the market competition has a significant negative effect on R&D investment ( $\beta=-0.144$ ,  $P<0.01$ ); After introducing R&D investment into the model, it can be found that market competition degree MC has no significant impact on innovation output Patent ( $p=0.310$ ), but R&D investment has a profoundly favorable effect on innovation output ( $\beta=0.267$ ,  $P<0.01$ ). In order to confirm whether there is a certain intermediary effect, the Bootstrap test of the model is further carried out, and it is found that 5,000 repeated samples are taken within the 90% confidence interval, indirectly. If the control variables are included, the regression coefficient of market competition is negative. This may be because the increasing market competition will bring pressure to enterprises, and the R&D investment will not bring immediate results, so the management of enterprises will have short-sighted behavior when faced with strong market competition, thus neglecting enterprise R&D expenditures.

**Table 3.** The intermediary effect of R&D investment

Variable	Dependent variable: R&D investment				Dependent variable: innovation output			
	$\beta$	se	t	p	$\beta$	se	t	p
MC	-0.144	0.034	-4.207	<0.01	0.035	0.035	1.016	0.310
RD ratio					0.267	0.037	7.252	<0.01
Year	0.109	0.035	3.141	<0.01	0.030	0.035	0.846	0.398
Size	-0.349	0.038	-9.103	<0.01	0.333	0.040	8.248	<0.01
RTA	-0.164	0.035	-4.729	<0.01	-0.018	0.035	-0.510	0.610
LEV	0.183	0.039	4.757	<0.01	0.127	0.039	3.248	<0.01
ROTE	0.039	0.036	1.094	0.274	0.004	0.036	0.110	0.913
AREA	0.170	0.088	1.929	0.054	-0.035	0.088	-0.399	0.690
R2		0.181				0.186		
F		23.231***				20.961***		

Note: \*\*\* means significant at the level of 1% level (double tail). se represents standard error, t means t value, and p means p value.

#### 4.3 The Adjustment Function of the Shareholding Ratio of Venture Capital

According to the application conditions, model in Hayes Conditional Process is selected here to analyze the regulating effect of the shareholding ratio of venture capital. Under the condition of controlling the age, scale, asset structure, profitability and region of the enterprise, the analysis results are shown in Table 4.

The results show that when the R&D investment of enterprises is listed as the dependent variable, the interaction between market competition degree and venture capital is significant ( $\beta=0.120$ ,  $P<0.05$ ), that is, when the market competition degree and venture capital act together, the R&D investment of enterprises will be promoted to some extent. When the firms' production of innovation is taken as the dependent variable, the interaction between venture funding and R&D investment in research is significant ( $\beta=0.245$ ,  $P<0.01$ ), which indicates that the interaction between R&D investment and venture capital will promote the innovation yield of enterprises. This might be the case since venture capital participation will encourage businesses to be innovative, and the support of funds will also provide enterprises with more power, so that enterprises can better face the fierce market competition.

**Table 4.** Analysis consequences of the moderating effect of the venture capital

Variable	Dependent variable: RD ratio				Dependent variable: Patent					
	$\beta$	se	t	p	$\beta$	se	t	p		
MC	-0.140	0.036	-3.891	<0.01	0.030	0.036	0.842	0.400		
RD ratio					0.287	0.050	5.723	<0.01		
VCSH	-0.026	0.035	-0.756	0.450	-0.008	0.037	-0.211	0.833		
MC×VCSH	0.120	0.049	2.424	<0.05						
RD ratio×VCSH					0.245	0.094	2.611	<0.01		
Year	0.076	0.036	2.131	<0.05	0.070	0.036	1.950	0.052		
Size	-0.183	0.036	-5.096	<0.01	0.150	0.036	4.131	<0.01		
RTA	-0.221	0.035	-6.264	<0.01	0.019	0.036	0.524	0.601		
LEV	0.082	0.037	2.198	<0.05	0.236	0.037	6.350	<0.01		
ROTE	-0.006	0.036	-0.175	0.861	0.048	0.036	1.338	0.181		
AREA	0.155	0.091	1.701	0.089	-0.037	0.091	-0.412	0.681		
R2		0.127					0.140			
F		11.867***					11.947***			

Note: \*\*\* means significant at the level of 1% level (double tail). se represents standard error, t means t value, and p means p value.

## 5. Conclusion and policy implication

Without R&D input, competition in the marketplace seems to have little direct influence on innovation. While R&D investment only has a partial intermediate effect on smaller-scale firms, it plays a full intermediary role in the adverse effects of market rivalry on innovation output. The influence of venture capital shareholding ratio of the related enterprises on R&D investment in marketplace competition. Path, R&D investment have active regulating effect on the influence path of innovation output, which accords with Hayes' conditional process model. In addition to the above two paths, the venture capital of small and medium-sized technology enterprises will positively adjust the path of the influence of market competition on the production of advancement by businesses. Shareholding ratios for high-risk investments have a higher regulatory impact than those for low-risk investments.

In accordance with the results of the above analysis, the following policy implications are put forward. First, to figure out the financing difficulties of the businesses in the research that are involved in science and technology, the government should create a fair competitive environment, and give equal treatment in factors acquisition, access permission, financial subsidies, industry supervision, investment and financing, and eliminate all kinds of explicit or implicit guarantees in the financing of state-owned enterprises, and protect them from fair financing and development opportunities. Second, venture capital and multi-level capital market should be actively cultivated. GEM, investment firms, and private equity are examples of the direct financing system and private placement bond is more in line with the financing needs of scientific and technological enterprises. At present, there are some problems in China's venture capital system, such as a small venture capital scale and immature operation mode. Third, China should continue to deepen the innovation-driven development strategy and promote the innovation progress of these companies mentioned above. It is necessary to strengthen tax preferential policies such as deduction of R&D expenses, encourage the previously mentioned technology companies that meet the requirements to increase R&D investment, and encourage medium and small businesses engaged in science and technology to improve their R&D capability and innovation level by various means such as legislation, taxation and finance.

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