Mediation Effect Analysis Between Firm Leverage, Competitive Intensity and Innovation Performance

Tianjian Lin[1,a,*]

[1]*School of Management and Economics, South China Normal University, Guangzhou, 510000, China*
a. 1696804430@qq.com
*corresponding author

Abstract: The business environment has become more severe in recent years because of the impact of trade friction between China and America and the global epidemic. To achieve long-term survival and development, enterprises must carry out innovative activities and develop new products to meet market demand. We use empirical analysis to study the mechanism of leverage on innovation performance based on the data of listed companies in the Shanghai and Shenzhen exchanges in 2022. This study shows that firms' leverage has a positive impact on their innovation performance, while firms' gross profit margins play a negative mediating effect in it. So, firm leverage can decrease gross margins and thus improve innovation performance.

Keywords: Innovation Performance, Firm Leverage, Competitive Intensity, Mediating Effect

1. Introduction

Technological innovation is a key determinant in changing China's economic development model from factor-driven to innovation-driven. China has also introduced several policies to encourage companies to innovate. As a result, more and more enterprises have been motivated by policies to increase innovation behavior. For example, of the more than 860 projects set up by the National Key R&D Program in 2021, more than 680 projects are led or participated by enterprises, accounting for as high as 79%. The innovative behavior of enterprises can not only provide impetus for the development of the company but also contribute to the transformation of the industry where the enterprise is located.

Firm innovation performance is affected by a variety of factors. Hu Wei et al. [1] found that policy incentives have a positive relationship with corporate innovation performance. Li [2] found that Firm equity concentration weakens the positive impact of government grants on innovation sustainability. Zhou et al. [3] found that the stability of the executive team has a direct impact on the innovation performance of the company. In addition to this, Philippe Aghion and Nick Bloom's [4] empirical study shows that the competitive environment of a firm can have an impact on the firm's innovation drive. There are few studies on the relationship between firm leverage on both competitive intensity and innovation performance.

We focus on the impact of leverage on the innovative performance of enterprises and beta, an indicator to compare the size of impact relationships. Compared with existing research, this paper introduces several variables and finds the mechanisms of leverage impact on innovation performance

by correlation and regression analysis. We attempt to provide directions and references for governments to promote the efficiency of market innovation.

2. Theory Basis

2.1. Firm Leverage and Innovation Performance

The ability to innovate is the main driver of a company's long-term competitive advantage [5], and the realization of corporate innovation requires a significant investment of capital. On the one hand, leverage can increase a business's cash flow, so that firms will invest more in R&D when risks are manageable. According to Xie Weimin's research, an increase in R&D investment has a positive effect on innovation performance [6]. So an increase in leverage will give firms more money to increase their innovation performance.

On the other hand, the higher debt of a firm indicates that it has a high utilization of funds, and funds per unit will be more fully utilized. So between two firms that spend the same amount of money on R&D, the more capital-utilized firm creates a better innovation performance. Increased leverage leads to better firm innovation performance.

Table 1: Definition of Variables

Variable Type	Variable	Notation	Calculation
Explained Variable	Innovation Performance	patent	$\ln(\text{patent} + 1)$
Explanatory Variable	Debt Ratio	Lev	leverage $\times$ 100%
Intermediary Variable	Competitiveness	GPM	Gross profit margin $\times$ 100%
Control variable	growth	growth	$\dfrac{(\text{BI in year x} - \text{BI in year (x} - 1)}{\text{BI in year (x} - 1)}$
	roe	roe	Return on equity $\times$ 100%
	R&D Cost	rd	$\ln(1 + \text{R\&D Cost})$
	R&D personnel	personnel	$\ln(\text{R\&D Personnel} + 1)$
	Size	size	$\ln(\text{ Major Customer Sales} + 1)$
	Age	age	$\dfrac{\text{Days}}{365}$
	Equity Concentration	top10	Total shareholding of top ten shareholders $\times$ 100%
	Government subsidies	subsidy	$\ln(\text{Subsidies} + 1)$

Based on the above analyses, this paper proposes research hypothesis H1 that leverage has a promoting effect on firms' innovation performance improvement.

2.2. Competiveness and Innovation Performance

Gross margin is a measure of the intensity of competition in the industry in which a company operates. The higher the firm's competitive intensity, i.e. the higher its market share or the better its differentiation strategy is implemented, the diminishing returns to the firm from innovative behavior. The smaller the returns, the less willing the firm is to engage in innovative behavior.

Based on the above analyses, this paper proposes research hypothesis H2 that competitiveness has an inhibitory effect on firms' innovation performance.

2.3. Firm Leverage and Competitiveness

Strongly competitive firms are usually in a monopoly position in their industry y, when the firm has a low level of leverage because it has a large amount of free cash flow and does not need to go into debt. Studies have shown a negative correlation between corporate leverage and competitiveness [7].

Based on the above analyses, this paper proposes research hypothesis H3 that firm leverage has an inhibitory effect on competitiveness.

3. Methodology

We use data from 1055 listed companies for correlation and regression analysis. Through the causal steps approach, we finally verify the mediating role of competitiveness between leverage and innovation performance using a stepwise approach.

3.1. Data sources

In this paper, we take all the A-share listed companies in Shanghai and Shenzhen as samples and collect their annual financial statement data for 2022. In the pre-processing, companies with the following conditions are excluded: (1) Part of the company's data is missing. (2) The company has been established for less than 5 years. (3) The company will receive government subsidies in 2022. (4) ST stocks, *ST stocks. Finally, 1055 samples of basic research that meet the requirements are obtained.

Table 2: Descriptive Statistics

VarName	Obs	Mean	SD	Median	P25	P75	Min	Max
patent	1055	5.146	1.465	5.112	4.234	5.971	0.693	11.289
gpm	1055	0.290	0.200	0.255	0.157	0.392	-0.750	0.954
lev	1055	0.402	0.214	0.390	0.221	0.551	0.032	1.144
roe	1055	-0.016	1.387	0.069	0.014	0.114	-43.005	0.902
rd	1055	18.208	1.480	18.104	17.301	19.028	12.531	24.046
personnel	1055	5.550	1.315	5.416	4.718	6.230	0.693	11.152
size	1055	19.312	1.662	19.123	18.202	20.295	10.170	25.522
age	1055	22.547	6.636	22.156	18.162	26.353	6.386	46.490
growth	1055	0.101	0.420	0.056	-0.085	0.211	-0.825	4.704
top10	1055	0.581	0.167	0.594	0.460	0.709	0.126	1.000

3.2. Variable Measurements

Innovation performance is the explanatory variable, measured using the number of firms' patents. Leverage is the explanatory variable, measured using the asset-liability ratio.

Intensity of competition is the intermediary variable, measured using firms' gross profit margin. A high gross margin indicates that the company's products or services are highly competitive, and accordingly, a low gross margin indicates that the company's products or services are less competitive.

Table 3: Correlation Analysis

	patent	gpm	lev	roe	rd	personnel	size	age	growth	top10	subsidy
patent	1										
gpm	-0.099***	1									
lev	0.237***	-0.561***	1								
roe	0.01	0.098***	-0.178***	1							
rd	0.600***	0.082***	0.151***	0.062**	1						
personnel	0.564***	-0.022	0.222***	0.029	0.861***	1					
size	0.338***	-0.342***	0.434***	0.01	0.463***	0.461***	1				
age	0.157***	-0.176***	0.273***	-0.036	0.051*	0.102***	0.201***	1			
growth	0.002	0.149***	0.063**	0.051*	0.119***	0.060*	0.165***	-0.057*	1		
top10	-0.062**	0.150***	-0.193***	0.070**	0.006	-0.03	0.072**	-0.225***	0.031	1	
subsidy	0.061**	0.083***	-0.098***	0.026	0.186***	0.148***	0.097***	-0.111***	0.021	0.234***	1

Control variables include firm growth, return on equity, R&D cost, R&D personnel, size, age, equity concentration and government subsidies.

In summary, the basic variables of this paper are shown in Table 1.

Table 2 shows the descriptive statistics of the main variables. As can be seen from the table, the mean value of innovation performance is 5.15 and the standard deviation is 1.47, which indicates that although they are listed companies, there are still big differences in innovation performance among different companies. The mean and median of leverage are 0.4 and 0.39 respectively, which indicates that most companies have normal levels of leverage without over-indebted. Similarly, factors such as return on equity, size, age, etc. vary significantly between firms. This shows the breadth of our selection of data, covering multiple industries, ensuring the generalization ability of our analysis.

3.3. Model Design

Based on the analysis above, we developed the following four models.

Model (1) is first constructed to test the relationships between leverage (Lev) and innovation performance (patent) and to test hypothesis H1.

$$patent = \beta_0 + \beta_1 Controls + \beta_2 Lev + \varepsilon \tag{1}$$

Model (2) is developed to verify the effect of competitiveness on firms' innovation performance and to test hypothesis H2.

$$patent = \beta_0 + \beta_1 gpm + \beta_2 Controls + \varepsilon \tag{2}$$

First, to verify the mediating effect of competitiveness, we refer to Wen Zhonglin's study [8] to prove the significant effect of the independent variable on the dependent variable. Second, we prove the significant effect of the independent variable on the mediator variable. Based on these two tests a mediating variable is added to the main effect, and if the independent variable and the mediating variable are significant at the same time, then the mediating variable is a partial mediator. Model (3) and model (4) were constructed based on model (1), in order to verify H3.

$$Lev = \beta_0 + \beta_1 Controls + \beta_3 gpm + \varepsilon \tag{3}$$

$$patent = \beta_0 + \beta_1 gpm + \beta_2 Controls + \beta_3 Lev + \varepsilon \tag{4}$$

4.   hypothesis testing

4.1. Correlation Analysis

Further Pearson correlation tests were conducted for each variable, and the specific test results are shown in Table 3.

As shown in Table 3, the correlation coefficient between leverage (Lev) and innovation performance (patent) is 0.237, at 1% significance level. This indicates that without considering the effect of control variables, there is a significant positive relationship between the two, which lays the foundation for the test of hypothesis H1. The coefficient of correlation between competitiveness (GPM) and innovation performance is -0.099 and significant at 1% significance level, which lays the groundwork for subsequent tests of mediating effects in this paper.

Table 4: Main Effects Test

VARIABLES	(1) patent	(2) patent
gpm		-0.813***
		(0.206)
lev	0.768***	
	(0.196)	
roe	0.00406	-0.00789
	(0.0260)	(0.0256)
rd	0.486***	0.513***
	(0.0484)	(0.0496)
personnel	0.123**	0.125**
	(0.0540)	(0.0539)
size	0.00823	0.00150
	(0.0273)	(0.0280)
age	0.0173***	0.0198***
	(0.00569)	(0.00564)
growth	-0.231***	-0.151*
	(0.0858)	(0.0875)
top10	-0.141	-0.148
	(0.228)	(0.227)
subsidy	-0.0131	-0.0160
	(0.0145)	(0.0145)
Constant	-4.967***	-4.806***
	(0.716)	(0.720)
Observations	1,055	1,055
R-squared	0.398	0.399

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Mediation Effect Test

VARIABLES	(3) gpm	(4) patent
gpm		-0.558**
		(0.232)
lev	-0.442***	0.522**
	(0.0261)	(0.221)
roe	-0.00231	0.00277
	(0.00345)	(0.0259)
rd	0.0464***	0.512***
	(0.00643)	(0.0495)

Table 5: (continued).

personnel	-0.0131*	0.116**
	(0.00718)	(0.0540)
size	-0.0360***	-0.0119
	(0.00363)	(0.0285)
age	0.000975	0.0178***
	(0.000757)	(0.00569)
growth	0.0919***	-0.179**
	(0.0114)	(0.0882)
top10	0.0957***	-0.0878
	(0.0303)	(0.228)
subsidy	-0.000294	-0.0133
	(0.00193)	(0.0145)
Constant	0.308***	-4.795***
	(0.0952)	(0.718)
Observations	1,055	1,055
R-squared	0.431	0.402

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Among the control variables, firms' research expenses, number of researchers, size, age, and government grants received are positively related to firms' innovation performance. This means that firms being larger, longer-lived and receiving more government subsidies can carry out relevant innovation activities more easily, which ultimately contributes to the promotion of firms' innovation performance.

The correlation test only analyses the correlation between two variables. The complex relationship between the variables and the mediation test requires further regression tests.

4.2. Main Effects Test

To verify the impact of leverage on the innovation performance of enterprises, we construct model (1). The results of model (1) in Table 4 indicate that the contribution of leverage to the innovation performance of firms is at 1% significant level, validating H1 of the paper. The check of model (2) in Table 4 shows that the inhibitory effect of competitiveness on innovation performance is at the significant level of 1%, validating H2 of the paper.

4.3. Mediation Effect Test

Model (3) in Table 5 focuses on the effect of the independent variable on the mediating variable. It shows that leverage significantly reduces firm competitiveness (β=-0.442, p<0.01). Next, we add both the independent variable (lev) and the mediator variable (GPM) to Model (4) in Table 5. Competitiveness shows a significant negative effect on innovation performance (β=-0.558, p<0.05) on the basis of the significant positive effect of leverage on innovation performance in Model (4) (β=0.522, p<0.05). Hypothesis H3 is tested because it means that competitiveness plays a partly mediating role.

5. Discussion

After empirical analysis, it was found that first, there is a positive relationship between leverage and firms' innovation performance. Leverage can provide firms with more capital, which can help them

in their innovation activities. Second, there is a negative relationship between leverage and competitiveness, so when firms become less leveraged, they are usually sufficiently competitive. Third, competitiveness mediates the effect of leverage on innovation performance. Competitive firms are usually in a monopoly position in their industry. The benefits of carrying out innovative activities are small, so firms will be less willing to innovate.

Through our analysis, we have two-fold suggestions.

From the perspective of governments and regulators, we have two suggestions. First is that limiting monopolistic behavior in the market and increasing the competitiveness of the market can help to improve the innovative performance of firms and even industries. Second, the country can improve enterprise financing channels, simplifying processes and relaxing conditions to provide financial support for innovative enterprises.

From the perspective of companies, we also have two suggestions. First is that choosing moderate leverage can increase innovation performance. Next is that when firms are in a monopoly position, undertaking innovative activities may lead to a weakening in their competitiveness.

6.   Conclusion

This paper conducts an empirical analysis based on data from the 2022 annual reports of companies listed on the SHSE and SZSE. We investigate the impact of leverage on the innovation performance of firms as well as the partially mediating role played by competitiveness in the relationship between the two. This paper provides insights on how to improve innovation performance in business as well as in government. We hope that further research will reveal the impact of other factors on innovation performance. More human decision-making behavior also has a considerable impact on innovation performance. Therefore, we also hope to find out the impact of executive decision-making on firms' innovative behavior in subsequent studies.

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