A Study on The Effect of Leverage Level on The Level of Innovation Output of Enterprises: A Threshold Regression Based on The Nature of Industry and Property Rights

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ABSTRACT
In the context of deepening supply-side structural reform, the implementation of the "deleveraging" policy may bring impact on the innovation output of enterprises, and the role of innovation for enterprises and countries is self-evident. Therefore, to explore the relationship between the two, the data of A-share listed industrial enterprises from 2014-2019 are used as a sample, and the threshold effect is tested and threshold regression is performed for samples with different property rights based on the nature of property rights, under the condition that the differences in indicators of each industry are controlled. The results indicate that: 1) for the overall enterprises, it is most beneficial to increase its innovation output level when its enterprise leverage level is less than 0.6782. 2) For SOEs, it is more favorable to improve their innovation output when their leverage level is less than 0.5862. 3) For non-state enterprises, there is no significant threshold effect between their leverage level and the level of innovation output.

Keywords: *enterprise leverage, enterprise innovation output, nature of industry, nature of property rights, large-sample data analysis.*

1. INTRODUCTION

In recent years, with the progress of supply-side structural reform, "deleveraging" has been promoted as one of the reform tasks. In 2015, the central government made "deleveraging" one of the five major tasks of supply-side structural reform. After 2018, with the introduction of policies such as "structural deleveraging", the leverage ratio of enterprises continues to decline, and "deleveraging" is still being promoted [21]. Simultaneously, innovation is undoubtedly important for development. The 19th Party Congress report proposed that innovation is the first driving force leading development and a strategic support for building a modern economic system. In recent years, the innovation ability of Chinese enterprises has been improving, and innovative achievements have been emerging, but on the whole, there is still a gap compared with advanced countries. Therefore, it is still an important task to promote the development of innovation and the construction of an innovative country. However, innovation is not easy for enterprises, and adequate capital reserves are often a necessity. When own funds are not enough, the innovation activities are bound to be financed by debt and other forms of financing to reduce the risks and stresses associated with innovation. So enterprises often utilize leverage to help them innovate. Therefore, in the process of deleveraging, the specific impact of leverage on innovation should be discussed.

Therefore, for one thing, studying the impact of enterprise leverage level on innovation output is conducive to opening the black box and revealing the intrinsic relationship between them; for another, it is conducive to the effective promotion of "deleveraging" while ensuring innovation. Previous studies have always combined enterprises from all industries in their analysis of this issue. However, it is not possible to generalize considering differences in capital intensity and innovation propensities in various industries. Moreover, with the introduction of the national "structural deleveraging", the promotion of the policy also requires relatively unified norms. In this regard, this paper further explores these issues from an empirical perspective.

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2. LITERATURE REVIEW

Existing studies addressed the relationship between the enterprise leverage and enterprise innovation and have obtained different conclusions: positive, negative and determined by different leverage intervals. Some argue that the increase in the overall level of enterprise leverage is beneficial to the increase in R&D investment and the number of patents granted for inventions [9]. Operating and commercial credit leverage can effectively drive enterprise technological innovation [13]. On the contrary, some argue that deleveraging policies will inhibit the level of innovation in the automotive industry [8]. Enterprise leverage has an inhibitory effect on enterprise innovation [1]. Increased enterprise leverage due to bank loans has a negative impact on both innovation investments [16]. A reduction in enterprise leverage level is beneficial to green innovation [12]. Leverage can promote innovation output when it is less than a certain value, while innovation risk increases when it is exceeded [15]. Either too low or too high leverage is not conducive to enterprise innovation [3]. Enterprise leverage has an "inverted U-shaped" relationship with innovation input and output [17]. From the literature, it can be further concluded that the relationship is usually assumed to be linear for literature with positive or negative correlations, while a non-linear relationship is usually assumed for literature with conclusions determined by different leverage ratio intervals.

At the same time, existing literature has categorized the study of enterprises in different industries and property rights and obtained different conclusions. In the relationship between leverage ratio and innovation output, state-owned enterprises are significant but non-state-owned enterprises are not, while high-tech industries are more significant [7]. Enterprises with different property rights have different optimal leverage intervals [6]. Compared with state-owned enterprises, non-state-owned enterprises are more suitable for increasing leverage ratio and are more effective in promoting their innovation [18].

In conclusion, the existing literature uses different research methods and draws different conclusions based on industry and property rights perspectives, which enriching our understanding of the relationship between enterprise leverage and innovation. However, the existing literature still suffers from the following shortcomings: for one thing, the existing studies usually classify industries only broadly, which leads to the indeterminate classification criteria, resulting in the difficulty to conclude on general policy criteria applicable for each industry; for another, the existing literature, based on a property rights perspective, does not take into account the requirements of leverage and innovation by industry and the impact of other factors that affect innovation differently. Therefore, this paper facilitates the adaptation to the different requirements of leverage and innovation in each industry and the formulation of policies based on this differentiation, through an industry-specific reconciliation of leverage and enterprise innovation capacity, as well as other indicators that affect innovation, and a joint analysis based on this perspective of property rights.

3. THEORETICAL ANALYSIS AND RESEARCH ASSUMPTIONS

The increased level of leverage for enterprises is a "double-edged sword" for their innovation activities. On the one hand, increasing the level of leverage may be conducive to improving their capacity for innovative activities and increasing their innovative output. Financing by increasing enterprise leverage can help them obtain more abundant capital for R&D investments. At the same time, debt financing, due to the tax shield, helps to reduce the cost of financing for enterprises [4], thus increasing their innovation effectiveness. Creditor oversight also helps to reduce the cost of enterprise supervision and optimize enterprise decision making [11], while promoting efficient enterprise innovation. On the other hand, increasing leverage may also act as a deterrent to enterprises' innovation activities, thereby inhibiting innovation output. When over-leveraged, enterprises are under more pressure to repay loans, which is detrimental to their ability to make the best use of their capital. Excessive leverage can also exacerbate a company's financial risk, like bankruptcy, which will increase when enterprises have difficulties in covering high financial costs [2]. Thus, the level of leverage has both a facilitating and inhibiting effect on enterprise innovation.

The above theoretical analysis shows that the relationship between the level of enterprise leverage and innovation output should not be attributed to a simple linear relationship but should be non-linear. That is, the level of leverage has different effects on enterprises' innovation output in the intervals where different leverage levels are located. At the same time, the nature of the industry to which the enterprise belongs affects both leverage and innovation output of the enterprise differently. Industries such as real estate, construction and manufacturing are more leveraged after the financial crisis [14], and high-tech industries also have higher innovation output requirements compared with traditional manufacturing. However, for each industry, the level of enterprise leverage should still retain a similar non-linear relationship with the level of innovation output. Based on the above analysis, this paper proposes hypothesis 1.

H1: There is a non-linear relationship between the level of enterprise leverage in each industry on their innovation output levels, i.e., their marginal impact on enterprise innovation output differs in different levels of leverage.

Also, the property rights attributes of the enterprise affect the relationship between leverage level and innovation capacity. In the context of China's national situation and policies, compared with private enterprises, state-owned enterprises are more prone to problems such as high number of institutional redundancies, poor efficiency, and difficulty in fully utilizing funds [20]. However, compared with private enterprises, state-owned enterprises can take advantage of property rights to broaden their own financing channels and reduce financing costs. At the same time, the conditions of external supervision by creditors are more conducive to promoting quality decision-making by SOEs and effectively improving their own innovation capabilities. Therefore, this paper proposes hypothesis 2.

H2: The leverage level of SOEs has a more significant impact on innovation compared with private enterprises.

4. MODEL SETTING AND DATA SOURCES

4.1 Model setting

According to theoretical analysis, the level of enterprises innovation rises with increasing leverage until it reaches a moderate level and falls with increasing leverage after it reached. Therefore, this paper introduces a single threshold regression model.

$$N_{it} = \mu_i + \boldsymbol{\theta X_{it}} + \beta_1 Lev_{it} F(Lev_{it} < \gamma) + \beta_2 Lev_{it} F(Lev_{it} \geq \gamma) + \varepsilon_{it} \quad (1)$$

Where N_{it} is the explanatory variable, and $\boldsymbol{X_{it}}$ is the matrix of control variables,Lev_{it} represents the level of enterprise leverage, and γ is the corresponding threshold value. $F(\cdot)$ is the indicator function. Where the function value takes 1 when the response condition $Lev_{it} < \gamma$ is met, otherwise it takes 0. By analogy, double as well as multiple threshold regression models are obtained.

At the same time, since the leverage ratio, the requirement of innovation capability and the level of other factors affecting innovation vary among enterprises within each industry, the explanatory variable N_{it} and the threshold variable Lev_{it} and the control variable x_{it} in this paper are treated as follows in order to control for the requirement of leverage level and innovation level in each of these industries.

$$k_{it,j}{}^{*} = \frac{k_{it,j}}{\overline{k_{t,j}}} \left(\overline{k_{t,j}} = \frac{1}{n}\sum_{i=1}^{n} k_{it,j}\right) \quad (2)$$

Above $k_{it,j}$ represents the explanatory variable, the threshold variable and all control variables. And (2) equation indicates that for all these variables, the industry mean for the current year is taken.

4.2 Variable selection

(1) Explained variable: innovation output ratio (Or)

The adjusted level of innovation output is expressed by dividing the industry average of the logarithm of patents by the logarithm of enterprise patents.

(2) Explanatory variable: enterprises leverage ratio (Levr)

The enterprise leverage ratio can effectively reflect the microstructure of an enterprise its capital [20]. In this paper, the leverage ratios of each industry are divided by the industry mean to adjust for the different leverage requirements of each industry.

(3) Control variables: Referring to the studies of Zhang Xinmin, Liu Qiren and others, the control variables were selected as enterprises' innovation input (lnrde), current ratio (Cur), growth rate of total assets (Grow) return on net assets (Pro) current asset turnover (Ope) and ownership (of), all of which were adjusted by dividing them by the current year's industry mean since industry heterogeneity in the control variables [10] [19].

The selection of each variable is shown in Table 1.

Table.1. Description of threshold model variables

Variable types	Variable name	Variable Symbol	Variable description
Explained variable	Innovation output ratio	or	Number of enterprise patents / industry average this year
Explanatory variable	Leverage ratio	Levr	Enterprise asset liability ratio / industry average this year
Control variable	Innovation input	lnrde	Logarithm of enterprise innovation capital investment / industry average this year
	Solvency	Cur	Current ratio (%) / industry average this year

Growth ability	Grow	Growth rate of total assets (%) / industry average this year
Profitability	Pro	Return on net assets (%) / industry average this year
Operating capacity	Ope	Turnover rate of current assets (%) / industry average this year
ownership	of	"1" means state-owned enterprise, "0" means non-state-owned enterprise

4.3 Data sources and sample description

Given that the study focuses on non-financial enterprises, this paper selects A-share listed industrial enterprises from the Wind database for a total of six years from 2014-2019 as the study sample. To avoid outliers from adversely affecting the study results, outliers of 1% before and after continuous variables are excluded from this paper. Also, to ensure the balanced panel needed for the threshold regression, the paper excludes enterprises with missing values in each year of data. Finally, this paper obtains a sample size of 8040 data from 2014-2019. This paper uses Stata 16.0 for data processing and regression.

5. ANALYSIS OF EMPIRICAL RESULTS

5.1 Descriptive statistics

Descriptive statistics are performed on the data obtained for each variable, and the results are shown in Table 2. As can be seen from the results in Table 2, since the explanatory variables as well as the leverage ratio are extremely close to 1, it indicates that in fact the share of each enterprise in the industry is roughly stable for each year from 2014-2019 without significant time trends. In addition, the comparison of the standard deviation of the two, as well as the maximum and minimum values, shows that the level of innovation output and leverage varies widely among enterprises. The standard deviations of R&D investment and operating capacity of enterprises are 0.0712 and 0 .4584 respectively, which are relatively small, indicating that the differences between listed enterprises in these aspects are relatively insignificant.

Table.2. Results of descriptive statistics of model variables

VarName	Mean	SD	Min	Max
or	1.0214	0.4705	0.0000	3.4452
Levr	0.9980	0.4566	0.1614	2.2982
lnrde	1.0243	0.0712	0.7645	1.2402
Cur	0.9188	0.7788	0.1688	5.3894
Grow	0.6732	1.4938	-2.9648	9.4948
Pro	0.7434	3.2419	-12.7056	21.1967
Ope	0.9089	0.4584	0.1489	2.8741
of	0.3216	0.4671	0.0000	1.0000

5.2 Benchmark analysis

In this paper, we draw on Hansen's threshold test to test for the presence of a threshold effect and the estimation of the threshold by self-sampling the sample [5]. In this study, the number of self-sampling is set to 50, and single, double and triple threshold effect tests are conducted, and the results are shown in Table 3.

From the test results, the single threshold test is significant for both the full sample and the subsample of SOEs, while the double and triple threshold tests have small F-values and are not significant, so the single threshold is taken for estimation and the assumption of H1 can be accepted here. For the subsample of non-SOEs, the single, double, and triple threshold tests are not significant, so it can be concluded that the enterprise leverage of non-SOEs has no significant effect on their

innovation output. Therefore, we can accept the assumption of H2 here.

Table.3. Threshold effect test

VARIABLES	Thresholds	F Value	P Value
Or (Full Sample)	Single	19.12	0.0000
	Double	9.62	0.2400
	Triple	9.78	0.3200
Or (Subsample of=1)	Single	16.98	0.0200
	Double	6.96	0.5400
	Triple	7.59	0.3600
Or (Subsample of=0)	Single	11.20	0.1800
	Double	8.54	0.2600
	Triple	7.91	0.5000

Based on the above analysis, the threshold estimates for each sample and the corresponding confidence intervals at the 95% confidence level are obtained as shown in Table 4. As can be seen from Table 4, the single threshold estimates for the full sample and the subsample of SOEs are 0.6782 and 0.5862, respectively.

Table.4. Estimation results of each sample threshold

VARIABLES	Threshold Value	95% Confidence Interval
Or (Full Sample)	0.6782	[0.6683,0.6825]
Or (Subsample of=1)	0.5862	[0.5596,0.5904]
Or (Subsample of=0)	——	——

5.3 Analysis of threshold regression results

Based on the above analysis, the results of the regression including single, double, and triple thresholds for each sample are shown in Table 5. Based on the threshold regression results, we can perform the following analysis.

For the regression results of the full sample, when the enterprise leverage level is less than a single threshold, i.e., Levr < 0.6782, its leverage shows a negative correlation with the enterprise's innovation output level, and the regression coefficient is -0.779; when Levr > 0.6782, they still show a negative correlation, but their absolute value decreases to 0.202, indicating that when the leverage level is greater than the threshold, the enterprise's innovation output level still decreases, but the rate of decrease is lower. Therefore, for the overall industry, enterprises with leverage level less than 0.6782 can maximize their innovation output level.

For the regression results of the subsample of state-owned enterprises, when the leverage level of enterprises is less than a single threshold, i.e., Levr < 0.5862, their leverage and the level of innovation output also show a negative correlation, but this relationship is not significant; while when Levr > 0.5862, the two show a significant negative correlation, but their absolute values increase, indicating that the level of innovation output of enterprises still declines and the rate of decline increases when the leverage level is greater than the threshold. It can be deduced that for SOEs, the leverage level of SOEs is more favorable when it is below 0.5862 to improve their innovation output level.

5.4 Robustness test

To ensure the validity of the experimental results and the rigor of the conclusions, the robustness test is carried out by means of variable substitution. This paper uses this year's min-max normalization for the interpreted variables and the interpreted variables according to industry classification.

$$k_{it,j}{}^{*} = \frac{k_{it,j} - \min(k_{it,j})}{\max(k_{it,j}) - \min(k_{it,j})} \tag{3}$$

Above $k_{it,j}$ represents the explanatory variable and the threshold variable. By replacing the explained variable and its measuring formula, the regression results are consistent with the present study, and the threshold relationship is still verified.

Table.5. Regression results for each sample threshold

VARIABLES	(1) Or (Full Sample)	(2) Or (Subsample of=1)	(3) Or (Subsample of=0)	(4) Or (Test Sample)
lnrde	1.948***	1.521***	2.257***	0.840***
	(10.15)	(5.19)	(9.28)	(8.70)
Cur	-0.027**	-0.027	-0.027**	-0.022***
	(-2.37)	(-1.04)	(-2.11)	(-5.04)
Grow	-0.001	0.001	-0.002	-0.003**
	(-0.55)	(0.34)	(-0.68)	(-2.29)
Pro	-0.001	0.003*	-0.002*	-0.001*
	(-1.00)	(1.78)	(-1.96)	(-1.92)
Ope	-0.042**	-0.028	-0.055**	-0.005
	(-2.13)	(-0.95)	(-2.06)	(-0.56)
0b._cat#c.Levr	-0.779***	-0.063	-0.695***	-0.048**
	(-3.11)	(-0.72)	(-2.97)	(-2.00)
1._cat#c.Levr	-0.202***	-0.257**	-0.168***	-0.029*
	(-4.27)	(-2.54)	(-3.55)	(-1.66)
2._cat#c.Levr	-0.095***	-0.000	-0.078**	0.034
	(-2.98)	(-0.01)	(-2.45)	(1.62)
3._cat#c.Levr	-0.063**	-0.038	-0.046	-0.013
	(-2.55)	(-1.11)	(-1.64)	(-0.49)
Constant	-0.817***	-0.414	-1.152***	-0.345***
	(-4.07)	(-1.33)	(-4.64)	(-3.50)
Observations	8,040	2,586	5,454	8,040
R-squared	0.3388	0.3170	0.3368	0.3176
Number of code	1,340	431	909	1340

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

6. CONCLUSIONS AND POLICY RECOMMENDATIONS

6.1 Research findings

Based on the nature of different industries and property rights, this paper uses A-share listed industrial enterprises for a total of six years from 2014-2019 as a research sample to investigate the effect of enterprise leverage level on the level of enterprise innovation output using a threshold regression model. The empirical results show that 1) for the overall enterprise, it is most beneficial to increase its innovation output level when its enterprise leverage level is less than 0.6782. 2) For SOEs, it is more beneficial for them to improve their innovation output when the level of enterprise leverage is less than 0.5862. (3) For non-state enterprises, there is no significant threshold effect between their leverage level and the level of enterprise innovation output. It follows that property rights are an important factor affecting the level of enterprise leverage on the level of enterprise innovation output.

6.2 Policy recommendations

Firstly, in the context of "deleveraging", the government should target different industries and enterprises with different property rights, and take into account the specific conditions and development requirements of different industries and enterprises with different property rights, instead of mixing them together. For enterprises in general, deleveraging is conducive to promoting higher levels of innovation output. In other words, on the whole, the participation of enterprises in the "deleveraging" policy is beneficial to their own development in the industry.

Secondly, for the government, the threshold effect of SOEs' leverage on innovation output is relatively more significant and should be considered when implementing

"deleveraging". For SOEs, they should respond to the "deleveraging" policy to ensure innovative vitality and lay a good foundation for their own development and competitive advantage in the industry.

Thirdly, for non-state enterprises, although there is no significant leverage effect, a moderate level of leverage should still be controlled, which is conducive to promoting its level of innovation output and thus grasping a long-term advantage in the competition within the industry.

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