R&D Cost Stickiness and Enterprise Performance Based on Empirical Test Using WEISS Model

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Abstract: As China's economy enters the new normal, scientific and technological innovation plays a more important role. This paper uses the WEISS model to measure the R&D cost viscosity of enterprises, and uses modeling tools to test the impact of enterprise R&D cost stickiness on performance. The research results show that the moderate R&D cost viscosity will have a positive effect on enterprise performance in the short term, and the positive action mechanism is more significant in non-state-owned enterprises; secondly, the higher the R&D cost viscosity, the more not conducive to the growth of enterprise long-term performance.

Keywords: modeling tools; R&D cost stickiness; enterprise performance; Weiss model

1 INTRODUCTION

As China's economy has entered a new normal, scientific and technological innovation plays a more important role. Companies have resolutely implemented the decisions and arrangements of the CPC Central Committee and the State Council to promote development through innovation, but there are also problems in some core technologies. In recent years, there is no lack of scholars to explore the influence mechanism of innovation investment, in order to improve the technological innovation ability of enterprises, and realize the healthy and rapid development of enterprises. Cost stickiness is an important content of the cost law, which is specifically manifested in the asymmetry between enterprise cost and business volume changes. The study of enterprise cost stickiness can help enterprises to open the "black box" of cost (management) behavior, which is one of the important contents in the research of enterprise management behavior. In the existing cost viscosity researches, the causes and influencing factors are more systematic, while the economic consequence research is more scattered; there are few researches on enterprise development cost viscosity. Modeling tools in mathematical statistics are one of the appropriate ways to study this problem. Based on that, this paper specifically studies the role relationship between R&D cost viscosity and enterprise performance, and discusses short-term performance and long-term performance respectively, enriches the specific content of enterprise cost viscosity research, and expands the theoretical framework of enterprise performance improvement mechanism.

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As for cost stickiness and enterprise performance, Anderson et al. (2007)[1] pointed out that appropriate cost stickiness indicates that enterprises have resource redundancy, and managers can respond to urgent market needs, buy more time for managers to make decisions, and reduce mistakes so as to promote enterprise performance. Ge (2017)[2] found through empirical research that different industries lead to different cost stickiness levels of enterprises in different industries, and believed that most listed companies in China have cost stickiness, but also proved that cost stickiness can significantly promote enterprise performance. Hou (2020)[3] believed that the enterprise resource redundancy and excessive investment behavior will enhance the cost stickiness, making the enterprises cannot cope with the changes in the external environment and damage the value of the enterprise.

Researches focusing on enterprise R&D activities are less, Hu (2017)[4] confirmed the existence of cost viscosity helped enterprise R&D investment, Wang et al. (2018)[5] pointed out the nonlinear relationship between R&D investment and main business income, which further confirmed the stickiness of R&D investment. Sun (2021)[6] discussed the relationship between R&D cost stickiness and technological innovation performance, focusing on R&D activity investment and R&D results represented by patent results, but did not expand to the scope of corporate continuing operations.

To sum up, many scholars have studied the relationship between cost stickiness and enterprise performance, but the conclusions are not unified, and there is a research gap in the relationship between R&D cost stickiness and enterprise value.

2 MECHANISM OF EMPIRICAL ANALYSIS

One view is that cost stickiness has a positive impact on businesses. As a resource buffer for enterprises to deal with environmental changes, cost viscosity is neutral and objectively exists in enterprises. Moderate cost viscosity is enterprise resource redundancy, indicating that the enterprise is in a state of stability, can reduce long-term adjustment cost and improve enterprise efficiency; and cost viscosity provides managers to calmly allocate resources, conducive to enterprise attempts in high-risk innovation activities. The existence of R&D cost stickiness is the performance of continuous and strengthening R&D, which has a direct impact on the sustainable operation and development of enterprises.

Another view is that cost stickiness has an inhibitory effect on enterprise development. From the perspective of financing, the existence of cost viscosity reduces the accuracy of the enterprise surplus forecast, which will then affect the investment willingness of external investors, and may bring financing constraints. From the perspective of operating risk, cost stickiness reflects the process in which the business risk is amplified with the change of operating income under the influence of external risk, which is determined by the enterprise asset characteristics and executive decision-making behavior, and it acts on the enterprise to increase the operation and decision-making risk of the enterprise. From the perspective of resource redundancy, the higher the cost viscosity level, the more the low liquidity redundancy is, which makes the enterprises cannot cope with the changes in the external environment and damage the value of the enterprise. Based on the above analysis, we propose the hypothesis:

Hypothesis 1a: Enterprise R&D cost stickiness has a positive effect on enterprise performance.

Hypothesis 1b: Enterprise R&D cost stickiness has a reverse inhibition effect on enterprise performance.

3 EMPIRICAL RESEARCH DESIGN

3.1 Source and Processing of the Data

3.1.1 Data Source

In this paper, the data of Shanghai and Shenzhen A-share listed companies from 2016 to 2020 were selected as samples and screened according to the following methods: (1) excluding samples with missing R&D expenditure data; (2) excluding samples that do not meet the viscosity calculation model of R&D cost; (3) excluding samples with incomplete data of other variables, and 1,077 samples were finally obtained. The research data mainly comes from WIND and CSMAR, and the variables with a large number of outliers are abbreviated using STATA 15.0.

3.1.2 Variable Measurement

(1) The explained variable

Enterprise performance usually refers to the results of the normal production and operation of the enterprise over a period of time. We select ROA to measure short-term performance, and Tobin Q to measure long-term performance. ①ROA is the financial performance index of enterprises, which shows the ability of enterprises to use all of their own assets to create profits. The molecule is the net profit, and the denominator is the average total assets. ROA is more susceptible to obvious manipulation, so that it can more truly reflect the short-term performance level of enterprises. ②Tobin Q serves as the market performance index of the enterprise, having strong operability and theoretical ability, which can effectively connect the real economy with the virtual economy. At the same time, combined with the enterprise's financial data and market data, It can more reflect the real market value of the enterprise. It is easy for investors to speculate on the long-term development.

(2) Interpretation variable

The explanatory variable in this paper is R&D cost viscosity (Sticky). Using Weiss model, the specific value of R&D cost viscosity is calculated as shown in equation 1:

$$Sticky_{i,t} = -(\log \frac{\Delta \mathrm{Cos}t}{\Delta Sale_{i,down}} - \log \frac{\Delta \mathrm{Cos}t}{\Delta Sale_{i,up}}) \qquad (1)$$

In the formula, i indicates the company number; up represents the latest revenue increasing at the end of the year, and down represents the latest revenue which declines from the end of the year. Δcost represents the change of enterprise R&D spending, and Δsale represents the change of operating revenue. There are two situations needed pay attention to: ①the logarithm cannot be calculated when the direction of change of R&D expenditure and the direction of change of income are different, and the data is invalid. ②When an enterprise's operating

income continues to increase or decrease within a year, it is impossible to compare the changes in costs when revenue rises and falls, and it is impossible to calculate cost stickiness, so that the data for that year is invalid. The Weiss model obtains negative values, and the opposite number is positive. The larger the value is indicates that the higher the viscosity of R&D cost is.

3.1.3 Control Variable

To reduce the endogenicity due to missing variables, we select the enterprise size as one of the control variables. The larger the scale of the enterprise reflected by the scale of the assets, the richer the resources the enterprise has, the more it can support its survival and development, and then promote the increase of enterprise performance. Enterprise growth and asset-liability ratio are also selected as the control variables. The annual growth rate of the main business revenue reflects the growth rate of the enterprise. The greater the growth rate is means that the better the enterprise growth, the stronger the sustainable profitability. The asset-liability ratio indicates the capital structure of enterprises. Reasonable use of debt can not only produce tax avoidance effect, but also make the enterprise have sufficient funds to support the development and promote enterprise performance.

The specific variable definitions are shown in Table 1:

Table 1: Variables definition table

Type	Variable name	Abbreviation	Account form
explained variable	Al capital earnings rate	ROA	Net profit / total average enterprise assets
	Tobin Q	TobinQ	Market value of enterprise assets / (total assets-net intangible assets-net goodwill)
explanatory variable	R&D cost stickiness	Sticky	Calculated using the Weiss model
controlled variable	Equity concentration	Top1	The largest shareholder holds the shareholding proportion
	Property nature	Soe	1 means State-owned enterprises, 0 means non-state-owned enterprises
	scale	Size	Natural logarithm of the total ending assets
	Enterprise growth	Growth	Annual growth rate of main business revenue
	asset-liability ratio	Lev	Total corporate liabilities / total assets
	trade	Ind	According to the 2012 edition of the Industry Classification Guidelines of Listed Companies, virtual variables are set in the secondary manufacturing industry, which belongs to one industry, otherwise 0
	year	Year	Virtual variable, belongs to a certain year to take 1, or otherwise take 0

3.2 Model Design

Based on the above theoretical analysis and Hausman test results, a time-fixed effect model is established to test the impact of R&D cost viscosity on the short-term and long-term performance of enterprises. The basic models are set as follows:

$$ROA_{i,t} = \alpha + \beta_1 Sticky_t + \gamma X_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

$$Tobin_{i,t} = \alpha + \beta_2 Sticky_t + \gamma X_{it} + \mu_i + \varepsilon_{it} \quad (3)$$

In the model (2) and (3), whether the R&D cost viscosity has a significant impact on the enterprise performance is judged according to whether the coefficients of the main explanatory variables are significant. A positive coefficient indicates a positive relationship between the two, while a negative relationship represents a negative relationship. X_{it} is for a series of control variables, which represents other factors affecting the outcome. μ_i is the time dummy variable. ε_{it} is the random perturbation term. The model further controls for the fixed effect of time.

4 EMPIRICAL ANALYSIS

4.1 Descriptive Statistics

As can be seen from Table 2, the minimum of R&D cost viscosity is -8.758; the maximum value is 11.07; the standard deviation is 2. Different enterprises differ very much, according to the mean value is 0.576, and the median value is 0.371, that shows that the R&D cost is relatively sticky and enterprises have differences in the control of R&D cost stickiness. Long-term performance Tobin Q value standard deviation of 1, It shows that the long-term performance of different enterprises varies greatly, that may be related to an overestimate or an underestimate of the market value. There are great differences between the two maximum values of equity concentration and asset-liability ratio. Enterprises are obviously different having different operating benefits. Some enterprises have poor debt repayment ability, which may face a debt crisis.

Table 2: Descriptive statistics

variable	N	mean	min	p50	max	sd
ROA	1077	0.024	-0.182	0.032	0.13	0.071
TobinQ	1077	2.093	0.991	1.72	5.09	1.106
Sticky	1077	0.576	-8.758	0.371	11.07	2.146
Growth	1077	0.06	-0.373	0.039	0.689	0.254
Lev	1077	0.436	0.031	0.432	2.47	0.216
Size	1077	22.25	20.55	22.1	24.57	1.11
Soe	1077	0.292	0	0	1	0.455
Top1	1077	31.98	3	29.9	81.1	14.3

4.2 Benchmark inspection

Table 3 shows the benchmark regression results. The adjusted goodness-of-fit of the two regression models are 35.3% and 21.6%, respectively. The fitting situation is good, and the model has strong explanatory power.

Table 3: The benchmark regression results

Variable name	ROA	TobinQ
Sticky	0.002***	-0.029**
	-2.6	(-2.05)
Growth	0.093***	0.790***
	-13.44	-6.67
Lev	-0.150***	-0.764***
	(-17.13)	(-5.12)
Size	0.010***	-0.326***
	-5.88	(-11.13)
Top1	0.001***	-0.003
	-5.83	(-1.55)
_cons	-0.188***	10.145***
	(-4.40)	-13.87
Year	control	control
N	1077	1077
r2_a	0.353	0.216
F	66.132	33.966

(1) In the multiple regression model with ROA as the dependent variable, the coefficient is 0.002> 0, which is significant at the 1% level, indicating that an appropriate R&D cost viscosity has a positive role in promoting the short-term performance of enterprises, confirming the hypothesis of 1a. The annual growth rate of the main business revenue is significantly and positively correlated with the short-term performance, in line with the expectations. The asset-liability ratio is significantly negatively correlated with short-term performance. With the increase of liabilities, financial risks increase,which is not conducive to enterprise short-term performance. The enterprise scale coefficient is significantly positive at the 1% level, indicating that there is a certain positive correlation between enterprise scale and short-term performance. Equity concentration is significantly and positively associated with enterprise short-term performance.

(2) In the multiple regression model with TobinQ as the dependent variable, the coefficient is -0.029<0, which is significant at the 5% level, indicating that the viscosity of R&D cost suppresses the long-term performance. Hypothesis 1b is confirmed within the range. Enterprise size is significantly negatively correlated with long-term performance, not consistent with expectations. Asset-liability ratio is significantly negatively correlated with long-term performance, Also, indicating that with the increase of liabilities, financial risks increase, which is not conducive to the performance of long-term performance of enterprises. Annual growth rate of main business revenue is significantly and positively associated with

long-term performance, and the degree of influence is higher than that of short-term performance, indicating that the better the growth of the enterprise, the more conducive to long-term sustainable and stable operation.

4.3 Expansion Test

Test the heterogeneity of property rights: the organizational form and governance structure between SOEs and non-state enterprises can affect the utilization efficiency of innovation investment resources and thus enterprise performance; R&D cost viscosity and technological innovation performance are more the result of the increased initiative, which is more conducive to optimize resource allocation, and the direct effect of R&D cost viscosity under financing constraints and market competition. Therefore, the property rights group regression test of R&D cost stickiness and short-term performance is conducted. The results of Table 4 show that R&D cost stickiness promoted enterprise performance, but it is more significant in non-state-owned enterprises, consistent with expectations.

Table 4: Distinguishes between property rights heterogeneity regression results

Variable name	**state-owned enterprises**	**Non-state-owned enterprises**
	ROA	***TobinQ***
Sticky	0.001	0.003**
	-0.96	-2.49
Growth	0.080***	0.097***
	-6.52	-11.51
Lev	-0.130***	-0.154***
	(-8.89)	(-14.38)
Size	0.011***	0.011***
	-4.03	-4.76
Top1	0.001***	0.001***
	-3.24	-5.13
_cons	-0.183***	-0.213***
	(-3.19)	(-3.82)
Year	control	control
N	314	763
r2_a	0.326	0.36
F	22.589	48.585

5 CONCLUSIONS

This paper takes the financial data of 2016-2020 listed companies in Shanghai and Shenzhen to 2020 as a sample, to study the impact of R&D cost stickiness on enterprise performance. The study found that there is a significant positive correlation between the R&D cost stickiness and the short-term enterprise performance. Moderate R&D cost stickiness has a positive effect on corporate performance in a short period. This facilitation is more pronounced in non-SOEs. There is a significant negative correlation between the R&D cost

stickiness and the long-term enterprise performance. It shows that the higher the viscosity of R&D cost, the more inconducive to the long-term sustainable and stable operation of the enterprise.

In general, the research conclusion provides empirical evidence for the study of internal cost rules of enterprises, also helps discuss the economic consequences of enterprise R&D innovation investment, but it is still limited by many factors such as the difficulty to obtain data and the cumbersome calculation process. It is suggested that managers correctly understand cost stickiness. On the premise of avoiding resource redundancy and overcapacity, they should fully consider cost stickiness in decision-making and give full play to the positive role of cost stickiness on listed companies.

This paper only discusses the relationship between cost stickiness and firm performance, but fails to draw conclusions about the relationship between cost anti-stickiness and firm performance. The relationship between cost anti-stickiness and firm performance requires further research. In addition, cost stickiness not only has an economic effect on corporate performance, but other economic consequences of cost stickiness, such as research on innovation investment and corporate risk, are also worth expanding and enriching.

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