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The Impact of R&D Capital Stock on Enterprise Innovation Performance: the Regulation of Absorptive Capacity

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Abstract: This study uses the perpetual inventory method to measure the R&D capital stock of a company and researches the relationship between enterprise R&D capital stock and innovation performance when absorptive capacity is a moderator. Using the data of 342 companies on the GEM of Shenzhen Stock Exchange from 2012 to 2016 as samples, this paper makes an empirical study with the method of hierarchical regression. The results show that the R&D capital stock formed by continuous R&D investment promotes the innovation performance of enterprises. When firms deal with new external knowledge, the impact of realized absorptive capacity on innovation performance is more significant than that of potential absorptive capacity, and the relationship between R&D capital stock and innovation performance is negatively moderated by realized absorptive capacity.
Keywords: R&D Capital Stock, Sustainable Inventory Method, Hierarchical Regression Method, Absorptive Capacity, Innovation Performance.

1. INTRODUCTION

The report of the 19th National Congress of the Communist Party of China has once again clearly pointed out that China is currently in the midst of a crucial period of transforming its development mode, upgrading its economic structure, and transforming old and new kinetic energy. The economy has changed from a high-speed growth stage to a high-quality development stage. The word innovation, with more than 50 appearance frequencies, became the hottest word in the 19th report. Under the guidance of the innovation-driven development strategy, the state has continuously increased its investment in innovation. In 2016, the total expenditure of national research and development (R&D) reached 1,567.7 billion yuan [1], a year-on-year increase of 10.64%. Among them, the enterprise R&D funds expenditure was 1,192.354 billion yuan, accounting for 76.06% of the total annual funding. In the great environment of technological innovation, should companies focus on the current innovation output or pay more attention to the cumulative amount of R&D expenditure when investing in R&D? How does the R&D capital stock accumulated after R&D capitalization affect the innovation performance of enterprises? How to measure the cumulative amount of R&D

investment in enterprises? What impact does the company's knowledge absorption capacity have on innovation performance?

Based on the above problems, this paper explores the reasonable calculation method of enterprise R&D capital stock, studies the role of enterprise R&D activities, knowledge absorptive capacity and innovation performance, constructs measurement model, empirically studies the relationship among the three, and expects to find the problem. The answer can provide feasible suggestions and provide a small force in the progress of China's scientific and technological innovation development.

2. LITERATURE REVIEW

Innovation performance is a measure of the effectiveness of corporate innovation activities. Relevant scholars not only combed the knowledge system of enterprise innovation performance in theory, but also combined the relevant cases and data for quantitative analysis. The main research focuses on two aspects. First, the impact of enterprise technology research and development factors on innovation performance, the long-term enterprise R&D investment is the source of enterprise innovation, helping companies to occupy market share and achieve high performance and high market value [2]. Facing the complex and ever-changing external environment, enterprises must integrate heterogeneous technical knowledge and integrate applications to enhance their core competitiveness, and the depth and breadth of internal technology diversification have a positive impact on corporate innovation performance [3]. In addition, technology mergers and acquisitions are a way for enterprises to expand, and they are also a means to quickly acquire external knowledge. They have positive effects on enterprise innovation ability and innovation performance [4], and can significantly enhance the dynamic capabilities, perception and recognition capabilities of enterprise technology innovation. Resource integration capabilities [5]. By increasing the company's own R&D capital investment [6] and expanding R&D openness [7], the company's innovation performance is significantly improved.

R&D investment is the main means for companies to achieve innovation, but innovation is not the result of short-term research and development, but the result of long-term research and development investment. The accumulated knowledge of long-term continuous R&D investment forms the R&D capital stock of the enterprise, which is the best indicator to measure the accumulated knowledge level of R&D investment [14], but at present, China's official statistics do not give R&D capital stock data of each region. Many scholars refer to the international research on the calculation method of R&D capital stock. Huang Yongfeng [15] applied the perpetual inventory method to estimate the capital stock of China's manufacturing sub-sector in 1985-1995. Jiang Yonghong [14] conducted in-depth research on perpetual inventory. After the law, the stock of R&D capital in China since 1952 was measured. The results show that the stock of R&D capital in China is generally growing, and the ratio of GDP to GDP is “N”-shaped. In addition, Wu Yanbing [16] constructed knowledge functions based on R&D capital stock, labor input and R&D output to analyze knowledge production

efficiency. On the other hand, in the process of transforming innovation investment into output, scholars such as Albort-Morant [18] proposed that knowledge absorption ability can improve enterprise technology and product optimization, and enhance corporate innovation performance [19]. The knowledge absorptive ability is the ability of enterprises to identify and digest external information and transform it into commercial use [20]. Knowledge absorptive ability is a key factor in achieving the stated goals of technological innovation activities. Enterprises with strong absorptive ability are more likely to identify new knowledge outside the organization, integrate and assimilate existing knowledge, and stimulate organizational innovation inspiration, thereby enhancing the independent innovation capability of enterprises. In summary, R&D capital stocks and absorptive ability are closely related to corporate innovation performance. However, few literatures empirically study the relationship between the three. This paper takes the R&D capital stock as the independent variable and constructs the corresponding measurement model with the absorptive ability as the adjustment variable. It explores the impact of the two types of absorptive ability on the R&D capital stock and the innovation performance of the enterprise, and uses the public data of the listed companies on the GEM of the Shenzhen Stock Exchange to verify the model.

3. HYPOTHESIS DEVELOPMENT

3.1 The relationship between R&D capital stock and enterprise innovation performance

R&D activities are the process of applying the knowledge created and accumulated to the improvement of existing technologies and the development of new products, and are the main driving force for technological progress. R&D investment will not be effective immediately, nor can it be achieved overnight. The transformation, application and innovation of knowledge is a long process. R&D investment will gradually weaken the effect of the current innovation output over time. The R&D capital stock is the value of the depreciation of the previous input value and the current input value, which can reflect the effective investment accumulated by the enterprise in R&D activities. R&D capital stock can be used as an input resource for R&D activities to support current R&D activities. Many studies have explored the impact of R&D capital stock on innovation output at the macro level. For example, Wang Peng et al [23] have shown that the increase of R&D capital stock can promote the level of regional technological innovation output. Liu Xiuling [24] also pointed out that the accumulation of regional R&D capital has increased the level of innovation output of enterprises.

Hence, we hypothesize:

Hypothesis 1: R&D capital stock is positively correlated with corporate innovation performance.

3.2 Regulation of absorption capacity

Cohen and Levinthal [1990] (1990) first defined absorptive capacity as the ability of firms to acquire external knowledge, digest knowledge and translate it into commercial use, allowing companies to better identify, integrate, internalize and apply external information. Zahra and George divide the absorptive capacity into two substructures: potential absorptive capacity and

realistic absorptive capacity. Relevant research shows that these two types of absorptive capacity have different effects on the innovation of enterprises. Cui Ningning et al. [27] believe that enterprises with strong absorptive capacity tend to cooperate and innovate, while enterprises with strong absorptive capacity have higher independent innovation ability. . Wang Jian et al. [28] scholars have shown that absorptive capacity can regulate the relationship between innovation balance index and firm performance. For a company, the potential for absorptive capacity means that the company is sensitive to external knowledge and can quickly respond to new knowledge of the external environment.

Hence, we hypothesize:

Hypothesis 2a: Potential absorptive capacity can positively adjust the relationship between R&D capital stock and corporate innovation performance.

Reality absorptive capacity is the ability of an enterprise to transform new knowledge into innovative performance through investment in internal R&D facilities and capabilities of related R&D personnel [28]. The strong absorption capacity of enterprises shows that enterprises are good at applying new knowledge to solve practical problems, so the absorption capacity can promote the output of enterprise innovation.

Hence, we hypothesize:

Hypothesis 2b: Potential absorptive capacity can positively adjust the relationship between R&D capital stock and corporate innovation performance.

4. METHOD AND RESULT

Based on the above theoretical analysis, the theoretical model of this paper is initially constructed:

$$PAT_{it} = \beta_0+\beta_1 RDS_{it}+\beta_2 \text{Absorb1}_{it} + \beta_4 RDS_{it} \times \text{Absorb1}_{it} + \beta_6 \text{Control}_{it} + \varepsilon$$

$$PAT_{it} = \beta_0+\beta_1 RDS_{it} + \beta_3 \text{Absorb2}_{it} + \beta_5 RDS_{it} \times \text{Absorb2}_{it} + \beta_6 \text{Control}_{it} + \varepsilon$$

PAT_{it} refers to enterprise innovation performance, RDS_{it} refers to R&D capital stock, Absorb1_{it} and Absorb2_{it} refer to potential absorptive ability and reality absorptive ability respectively, Control_{it} refers to control variables.

This paper selects the data of the Shenzhen Stock Exchange GEM, mainly considering that the GEM companies are mainly engaged in high-tech business, have high growth, frequent R&D activities, and will continue to innovate due to market pressure. Since the GEM of the Shenzhen Stock Exchange was only launched in October 2009, in order to ensure sufficient sample, the data of the public financial statements of enterprises listed between 2009 and 2012 listed between 2009 and 2012 were excluded, and the companies that did not disclose R&D investment were excluded. After the ST listed companies, 342 samples were obtained.

The financial statement data and corporate governance data of all companies are obtained by hand-collecting from Guotaian CSMAR database and Juchao Information official website. The

patent data is manually searched through the patent database in the official website of the State Intellectual Property Office.

Table 1. Variable definition and measurement method

Variable type	Variable symbol	Variable name	Variable definition
Dependent variable	pat	Innovation performance	Number of patent licenses
Independent variable	rds	R&D Capital stock	The amount of enterprise R&D investment accumulated, using the perpetual inventory method to calculate the natural logarithm
Moderator	absorb	Absorptive ability	Absorb_1: Potential absorptive ability = number of technical R&D personnel / total number of employees Absorb_2: reality absorptive ability = R&D expenditure / main business income
Control variable	size	Business scale	The natural logarithm of the total assets of the enterprise
	age	Business age	The natural logarithm of the difference between the year of observation and the year of establishment
	lev	Assets and liabilities	The ratio of the total liabilities at the end of the period to the total assets at the end of the period
	roe	Profitability	Ratio of annual net profit to total operating income
	grow	Growth ability	Main business growth rate

5. MODEL TESTING AND DISCUSSION

The study used STATA14.0 statistical analysis software to process and analyze sample data. Table 2 shows the descriptive statistical analysis and correlation coefficient of the variables involved in this study. It can be seen that the average number of patents granted by enterprises in the sample from 2012 to 2016 is 5.899, which represents the average innovation performance of the sample companies during the five years. The standard deviation is 10.058, which indicates that the innovation level among enterprises is uneven and the difference is large. In contrast, the difference in R&D capital stock and absorptive capacity of enterprises is small, and the investment in R&D by each company is not much different. The variance expansion factor test was performed on the variables, and the vif values of all variables were less than 5, so the sample did not have a multicollinearity problem.

The panel data used in this paper belongs to short panel data. In this study, [35] hierarchical regression method is used to introduce control variables, independent variables, regulatory variables, and interaction variables between regulatory variables and independent variables into regression models to test the research hypotheses proposed above. The results are shown in Table 3.

Table 2. Descriptive statistical analysis of sample data and variable correlation coefficient

variable	pat	lnrds	absor1	absor2	size	lev	roe	grow	age
pat	1								
lnrds	0.222***	1							
absor1	-0.046*	0.197***	1						
absor2	-0.027*	0.369***	0.502***	1					
size	0.272***	0.553***	-0.111***	-0.107***	1				
lev	0.126***	0.189***	-0.219***	-0.284***	0.479***	1			
roe	0.00500	-0.0350	0.209***	0.086***	0.0140	-0.326***	1		
grow	0.107***	0.0320	-0.0140	-0.121***	0.268***	0.246***	0.099***	1	
age	-0.064***	0.096***	-0.047*	-0.0340	0.128***	0.100***	-0.069***	-0.0160	1
Mean	5.899	18.374	0.243	0.073	21.166	0.269	0 .122	0 .279	2.577
S.D.	10.058	0.950	0 .187	0.070	0.727	0.158	0.139	0.477	0.292
Min	0	13.653	0	0 .001	19.544	0.011	-1.857	-0.652	1.609
Max	139.2	21.983	0.963	0 .728	24.196	0 .843	0.908	5.802	3.401
VIF	——	2.04	1.42	1.74	2.18	1.67	1.25	1.15	1.03

Table 3. Result of hierarchical regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	model1	model2	model3	model4	model5	model6	model7
VARIABLES	pat	pat	pat	pat	pat	pat	pat
lnrds		2.974***	2.928***	3.482***	2.497***	2.924***	3.283***
		(4.488)	(4.402)	(4.394)	(3.505)	(3.962)	(3.949)
absor1			1.454	35.59			27.72
			(0.823)	(1.337)			(1.018)
lnrdsabsor1				-1.882			-1.482
				(-1.285)			(-0.989)
absor2					11.21*	214.1**	192.0**
					(1.814)	(2.294)	(2.009)
lnrdsabsor2						-10.48**	-9.334*
						(-2.179)	(-1.895)
size	3.413***	1.801**	1.846**	1.827**	2.102***	2.294***	2.286***
	(5.146)	(2.400)	(2.454)	(2.429)	(2.738)	(2.972)	(2.958)
lev	2.288	1.795	2.011	2.008	2.402	2.775	2.862
	(0.879)	(0.693)	(0.773)	(0.772)	(0.921)	(1.063)	(1.093)
roe	-0.718	-0.661	-0.767	-0.744	-0.0295	0.0881	0.0357
	(-0.414)	(-0.384)	(-0.444)	(-0.431)	(-0.0168)	(0.0502)	(0.0202)
grow	1.028**	1.186***	1.183***	1.190***	1.309***	1.426***	1.418***
	(2.299)	(2.662)	(2.655)	(2.671)	(2.908)	(3.150)	(3.129)
age	-10.85***	-14.91***	-14.65***	-14.97***	-14.35***	-14.63***	-14.69***
	(-4.618)	(-5.958)	(-5.802)	(-5.903)	(-5.694)	(-5.804)	(-5.769)
Constant	-39.20***	-49.18***	-50.37***	-59.14***	-49.34***	-61.16***	-67.46***
	(-3.731)	(-4.610)	(-4.678)	(-4.640)	(-4.629)	(-5.119)	(-5.053)
R-squared	0.036	0.050	0.051	0.052	0.053	0.056	0.057
Ajusted R2	0.029	0.072	0.079	0.082	0.080	0.081	0.085

From the model2 regression results in Table 3, it can be seen that the R&D capital stock has a significant positive effect on the company's innovation performance ($\beta = 2.974$, $p < 0.01$), and the assumption 1 is established. The results of model3 and model4 indicate that there is no

significant correlation between the potential absorptive capacity of the firm and the innovation performance of the firm, assuming that 2a does not hold. From model5 and model6, it is found that there is a significant positive correlation between the actual absorption capacity and the enterprise innovation performance ($\beta = 11.21$, $p < 0.1$). After adding the interaction term, the adjusted R square of the model increases, and the interaction coefficient is negative and significant. ($\beta = -10.48$, $p < 0.05$), indicating that the actual absorptive capacity has a negative adjustment effect on the relationship between R&D capital stock and enterprise innovation performance, assuming that 2b does not hold.

6. CONCLUSION AND MANAGEMENT IMPLICATIONS

The research results show that (1) enterprises with long-term investment in research and development, R&D capital stock is strong, and enterprises obtain higher innovation performance. (2) There is no significant relationship between the potential absorptive capacity measured by human capital and the innovation performance of enterprises. (3) The actual absorption capacity positively affects the innovation performance of enterprises, and has a negative adjustment effect on the relationship between R&D capital stock and enterprise innovation performance.

Based on the research conclusions of this paper, the following management inspirations are drawn: First, innovation needs to be continuously invested in research and development, thereby accumulating intangible knowledge assets of enterprises and obtaining stable innovation results of enterprises. For example, Huawei's accumulated R&D investment in the past 10 years was 394 billion yuan, and R&D investment accounted for 10% of sales revenue per year. In 2017, R&D investment was 89.7 billion yuan, accounting for nearly 15%. It is this continuous and steady investment in research and development that allows Huawei to take the lead in the industry. Secondly, from the perspective of absorptive capacity, the actual absorptive capacity of R&D expenditure and operating income as the proxy variable has a greater impact on the innovation performance of enterprises. When the enterprise pays attention to new knowledge and is good at transforming applications, R&D capital stock is innovative performance. The positive impact is weakened. For emerging R&D companies with weak R&D, they can explore the incentives to transform new knowledge by investing R&D expenditures in the organization. When investing in R&D, enterprises should allocate R&D expenditure reasonably and focus on improving the ability to apply new knowledge within the organization.

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