

An Empirical Study on the Relationship between R&D Investment and Firm Performance

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Abstract

Technological innovation is the soul of the core competitiveness of enterprises, and research and development is the source of enterprise innovation. The pharmaceutical manufacturing industry attaches great importance to and invests heavily in R&D activities. By selecting 137 pharmaceutical manufacturing companies from 2012 to 2019 as research samples, based on Schumpeter's innovation theory, this paper examines the relationship between R&D investment and firm performance. The results show that there is a nonlinear relationship between R&D investment and firm performance. When considering firm size and ownership structure, R&D investment intensity is significantly negatively correlated with firm performance. There is no threshold effect of equity multiplier on the relationship between R&D investment and firm performance. In order to achieve long-term development, enterprises must attach importance to R&D and innovation, measure their own reality, reasonably arrange R&D investment and expenditure, and combine short-term benefits with long-term benefits.

Keywords

R&D Investment; Firm Performance; Threshold Effect.

1. Introduction

Since the beginning of the 21st century, profound changes have taken place in the global economic and technological landscape. Technological innovation has become an important factor to promote economic growth, enhance technological competitiveness and master the voice of international discourse. However, the innovation capability of enterprises is depended on the investment in research and development. The report of the 19th National Congress of the Communist Party of China points out that China's economy is in the critical period of transforming the development mode, optimizing the economic structure and transforming the growth drivers. Accelerating the construction of an innovation-oriented country is an important measure to construct a modernized economic system [1]. "Fourteenth Five-Year Plan" also emphasizes the in-depth implementation of the innovation-driven development strategy, further emphasizing the important role of technological innovation in the economic transformation to high-quality development, and research and development investment is an essential pre-link of technological innovation, so China continues to increase the investment in research and development funds. According to the release of the National Bureau of Statistics, the intensity of China's R&D investment reached a new high in 2019, with a total investment of 2,214.36 billion yuan, and the intensity of R&D investment increased to 2.23%. From the perspective of the main body of R&D activities, the R&D expenditure of enterprises reached 1692.18 billion yuan in 2019, accounting for 76.4% of the national R&D expenditure [2]. In addition, the state has also introduced a number of policies, such as additional tax deductions for research and development expenses, corporate income tax, VAT preferential treatment, to encourage enterprises to increase investment in research and development and improve the core competitiveness of enterprises.

2. Literature Review

As early as the 1970s, the relationship between R&D investment and enterprise performance has attracted the attention of foreign economists. In Hyeock Lee, shows that R&D investment has a horizontally inverted S-shaped relationship with performance reflecting cost leadership, stuck in the middle, and differentiation strategies [3]. Ike C. Ehie shows that investment in R&D contributes positively to firm performance for both manufacturing and service firms, despite major economic disruptions [4]. Luca Berchicci suggest that firms that increasingly rely on external R&D activities have a better innovative performance, yet up to a point. Beyond this threshold, a greater share of external R&D activities reduces a firm's innovative performance [5]. Md. Samsul Alam Using a firm-level data for the period 2004 2016 from G-6 countries, this study empirically investigates how R&D investment affects the firm environmental performance measured by energy and carbon emissions intensities [6]. David DiweiLva found a firm's R&D investment is endogenous to performance comparisons, this feedback effect has an asymmetric effect on R&D investing behavior: inconsistent (consistent) performance feedback decreases (increases) the R&D intensity of the firm [7]. Tse Caleb H, found Local government support positively moderates the effect of R&D investment on their local subsidiaries' performance. The effects of this relationship are stronger for international joint ventures than for wholly owned subsidiaries [8]. In China, the research on the correlation between R&D investment and firm performance started relatively late, but it has always been the focus of research. At the same time, due to the limitation of the data, the sample enterprises studying related problems are concentrated in the listed companies. There are two completely different views on the relationship between R&D investment and firm performance in China. Some scholars believe that there is a significant positive correlation between the two factors, while others believe that there is no significant correlation between the two factors. Therefore, the academic circle has not reached a consensus on the relationship between domestic listed enterprises' R&D investment and enterprise performance. Xueying Yuan adopted the method of case study and found that there is a positive correlation between R&D investment and enterprise performance [9]. QiuYun Jie using tend to score matching method (PSM) to investigate the effect of R&D investment on enterprise performance, the study shows that the enterprise research and development of behavior can effectively promote its own performance, R&D enterprises exist the total factor productivity and profitability levels than no research and development of enterprise high about 3% [10]. Jian Zhang analyzed the R&D activities of listed companies and their performance in the current year and subsequent two years, and found that there was a significant negative correlation between the two [11]. Weiping Jiang found that the intensity of enterprise R&D investment has some connection with the current performance, while significantly positively correlated with the performance of enterprises in the first to third lag periods [11]. Heng Cheng found that the input of R&D personnel in high-tech industries significantly promoted the improvement of industrial science and technology performance, and both technology introduction, transformation and innovation had negative effects on science and technology performance to some extent [12]. Yajing Zhong took 40 listed companies in China's automobile manufacturing industry as research samples, and confirmed that when enterprises increase their R&D input, their current performance improved. The research and development investment has cumulative and lag effects, and the current research and development investment has a promotion effect on future performance research. Development investment has a relatively short delay of about one year in improving enterprise performance [13].

3. Study Design

3.1. Sample

This paper is based on the empirical research of pharmaceutical manufacturing enterprises listed in Shanghai and Shenzhen A-shares before the end of 2019. According to China Securities Regulatory Commission Industry Classification Standard (CSRC Industry Classification Standard), enterprises in pharmaceutical manufacturing industry are selected sample sources. This paper selects the financial data of sample enterprises from 2012 to 2019 as the research object. In order to reduce statistical errors, the original data were screened, according to the following conditions: During the study period, enterprises beginning with ST and *ST and PT that received special treatment and faced delisting warning were excluded. The samples of enterprises listed after 2012 were excluded. The enterprises with incomplete financial data during the research period were excluded. According to the above principles, 137 qualified samples were selected from all the samples, and the data of R&D expense, R&D investment intensity, return on total assets (ROA), shareholding ratio of top ten shareholders, equity multiplier, total market value and so on were mainly collected. The main data source for this paper is Wind database. Statistical software STATA 14.0, SPSS and Excel2010 were used for data analysis and processing in this paper.

3.2. Variable Definition

In this paper, return on assets is used to measuring enterprise performance. Measured by the ratio of corporate profits to total assets, ROA is a financial indicator commonly used to reflect corporate performance in existing literature. Research and development investment intensity (R&D). Research and development investment intensity is the most widely used index to measure enterprise's research and development investment, which is expressed by the ratio of total research and development investment to enterprise's sales revenue. Compared with the total index, the intensity of R&D investment can better reflect the R&D investment that is suitable for the size and market position of enterprises, and it is more comparable among different enterprises. Based on a large number of relevant literatures, select three control variables to explain the difference between R&D investment intensity and firm performance. First, the size of the enterprise, measured by the total market capitalization, which is the total value of the stock multiplied by the stock price at that time. Second, ownership structure. In order to reflect the impact of R&D intensity on corporate performance, this paper chooses the total shareholding ratio of the top ten shareholders as a substitute variable of ownership structure. Third, equity multiplier. Equity multiplier refers to the reciprocal of the proportion of shareholders' equity, which reflects the multiple relationship between the total assets and the total shareholders' equity. A large equity multiplier indicates that an enterprise has more liabilities.

Table 1. Variable definition and description

Variable	Variable name	Variable symbol	Variable
Dependent variable	Enterprise performance	roa	Dependent variable
independent variable	Research and development investment intensity	qd	independent variable
Threshold variable	The total market value	sz	Threshold variable

4. Empirical Analysis

In this paper, STATA 14.0 was used to conducting regression analysis and empirical hypothesis on the 8-year balance panel data. Before the regression analysis, Hausman test was used to

judge the regression model used in this paper. The calculated P value was 0.0000, far less than 0.05, so the regression model selected in this paper was a fixed-effect model.

4.1. Descriptive Statistics

Table 2. Descriptive statistics of variables

Variables	Obs.	Mean	Std. dev.	Min	Max
roa	1,096	8.441	7.817	-72.61	42.76
qd	1,096	4.699	4.255	0.0300	52.61
gd	1,096	56.56	14.97	10.57	92.79
qycs	1,096	1.684	1.120	1.025	22.22
sz	1,096	1.300e+10	1.990e+10	3.220e+08	3.870e+11

According to the results of descriptive statistics in Table 2, our country medicine manufacturing industry's average return on assets (ROA) was 8.4%. The pharmaceutical manufacturing industry from 2012 to 2019 the average R&D intensity (R&D) is 4.7%, the maximum of 52.6%, the minimum value is 0.03%. It has some difference from pharmaceutical manufacturing, ownership structure average of 56.56%, that there is a certain balance between the shareholders.

4.2. Correlation Analysis

Table 3. Correlation analysis of major variables

Variables	roa	qd	gd.	qqcs	sz
roa	1.000				
qd	-0.064*	1.000			
gd	0.194*	0.035	1.000		
qycs	-0.27*	-0.093*	-0.100*	1.000	
sz	0.3247	0.1321*	0.241*	-0.079*	1.000

Table 3 tests the correlation between the variables. "Research and development investment intensity" has some connection with firm performance at the 95% significance level. Ownership structure has some connection with firm performance, equity multiplier has some connection with firm performance, and total market value has some connection with firm performance. From the correlation coefficient between the variables, there is no multi-collinearity among the variables.

4.3. Threshold Regression Analysis

4.3.1. Take Market Capitalization as the Threshold Variable

In this section, market value is elected to be the threshold variable to study the structural abrupt (nonlinear) relationship between R&D investment intensity and return on assets. Table 4 shows the test results of threshold effect with market value as the threshold variable. Table 4 shows that the double threshold effect is significant at the 1% level, that is, the impact of enterprise R&D investment intensity on return on assets is non-linear, and there is a threshold effect based on market value. In addition, the threshold effect of triple threshold is not significant, so built a double threshold regression model based on market value. Table 5 shows the single threshold regression model under the 95% threshold value and the level of the confidence interval of.

Table 4. Threshold effect test results

Type of threshold effect	The F value	The P value	The critical value		
			10%	5%	1%
Single threshold effect	36.19***	0.0033	15.9246	20.9613	26.7801
double threshold effect	21.95***	0.0067	12.2717	16.2633	19.4886
Triple threshold effect	11.25	0.3700	18.9729	21.5469	27.3654

Note: The Bootstrap method for repeated sampling for 300 times (The same below)

Table 5. Threshold value of threshold effect inspection: the estimate and its confidence interval

The threshold value	95% confidence interval
22.3025	[22.24162,2.3051]
22.3025	[22.2404,22.3051]
23.9948	[22.7803,22.9015]

Table 6 shows the coefficient test results of the dual threshold regression model based on market capitalization. As can be seen from Table 6, except the coefficient of equity multiplier is not significant. Other variables were significant at the 1% level. When the enterprise value is less than 22.3025. The intensity of R&D investment impact on enterprise performance is 1.07. When the enterprise value is greater than 22.3025, less than 23.9948, the R&D input intensity impact on enterprise performance coefficient is 0.58. When market value is greater than 23.9948, the R&D input intensity impact on enterprise performance coefficient is 0.25, it shows that the enterprise scale can promote the growth of R&D intensity of performance, and larger businesses invest R&D spending can promote the growth of enterprise performance. Equations (1) and (2) reflect the specific form of threshold regression model based on market value.

$$ROA = -9.5692 - 1.003496 * qd (sz < 22.3051) - 0.4867605 * qd (sz > 22.3051) \tag{1}$$

$$ROA = 9.301336 - 1.070329 qd * (sz < 22.3025) - 0.58289786 * qd * (22.3025 < sz < 23.9948) + 0.2501793 * qd * (sz > 23.9948) \tag{2}$$

Table 6. Threshold regression model results

variable	coefficient test
qd(sz ≤ 22.3025)	-1.070329 *** (.1052267)
rd(22.3025 < fzl ≤ 23.9948)	-0.5828978 *** (.0767119 1)
rd(fzl > 23.9948)	-0.2501793 *** (.0941576)
qycs	-1.421409 (.2133462)
gd	0.0825619* (.0273199)
Constant term	9.301336 ***

5. Conclusion

Based on the sample data of Chinese pharmaceutical manufacturing enterprises from 2012 to 2019, this paper empirically analyzes the relationship between R&D investment intensity and firm performance, and further analyzes the possible differences of the relationship between R&D investment intensity and firm performance under different firm sizes and shareholding institutions. In general, R&D investment intensity has a complex nonlinear effect on firm performance, and the specific effect of R&D investment intensity on firm performance depends on the size of the firm and the size of ownership structure. Through threshold regression, the study found that there is a double threshold effect based on firm size and ownership structure between R&D investment and firm performance in pharmaceutical manufacturing industry. And in the case of enterprise scale and ownership structure must be, will not be positive promoting effect on the performance of corporate R&D input. Investigate its reason, on the one hand, is a research and development has a long-term, risk and instability, R&D activity is a continuous process, its influence on enterprises is a long-term, short-term hard to work, so in the case of enterprise scale and ownership structure must be, R&D intensity is negatively related to the role of the performance. On the other hand, R&D investment is the beginning of the enterprise's R&D activities, and it is an important guarantee for the continuous and smooth completion of R&D activities. To a certain extent, the amount of R&D investment often determines the level of enterprise performance, but the relationship between R&D investment intensity and enterprise performance is not absolute, enterprises should consider the long-term in the R&D investment decision, pay attention to the enterprise's own situation, and act according to their ability.

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