

Research on threshold effect of R&D Investment on Enterprise performance

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Abstract. This paper examines the threshold effect between R&D intensity and firm performance based on the panel threshold regression model. The results show that there is a double threshold effect on the impact of R&D input intensity on firm performance. Only when the R&D investment is in the optimal range can the company's performance be significantly improved.

1. Introduction

In recent years, R&D activities have received a lot of attention from all walks of life. Many scholars have carried out different angles of research around R&D activities. The relationship between R&D investment and enterprise performance has always been the focus of scholars. Due to the high investment, long cycle and slow effect of R&D activities, the relationship between R&D investment and enterprise performance is more complicated. Is there a linear relationship or a non-linear relationship between the two? If it is a nonlinear relationship, what is the impact path? How to determine the threshold value in the nonlinear relationship? Only by clarifying these issues can we fully grasp the relationship between the two, so that R&D investment measures and science and technology support policies can play a better role.

2. Literature review and research assumptions

Numerous studies have shown a close relationship between R&D investment and corporate performance. Martin's research on 3,700 Australian companies shows that R&D intensity has a significant positive impact on business growth [1]. Zhang Linhong et al. found that R&D investment has a negative impact on the performance of the company in the current year and beyond [2]. At the same time, more and more scholars are more convinced that R&D investment has a non-linear impact on corporate performance. Dai Xiaoyong et al. believe that there is an inverted N-type cubic curve relationship between R&D investment and firm performance [3]. Ye Songqin et al. used ZTE as an example to prove that there is a positive U-shaped effect between the two [4]. Hartmann et al. pointed out that companies can't simply pursue greater R&D investment. Corporate performance will not increase to a certain extent after R&D investment exceeds a certain critical point [5]. Therefore, scholars who hold this view generally believe that there is an optimal R&D input interval, which has led to a significant increase in corporate performance.

Based on the above point of view, this paper proposes the following research hypothesis: There is a threshold effect on the impact of R&D investment on firm performance. Only when R&D input intensity reaches a certain threshold will the performance of the enterprise be significantly improved. If the threshold is exceeded, the impact on firm performance will be weakened. It even has a negative impact.

3. Research design

This paper selects China's A-share listed companies as research samples from 2015 to 2017, and after data processing, it has obtained 12,480 data from 832 companies. The data comes from Csmar database and Wind database, and the statistical analysis software is stata13.0.

This paper uses the panel threshold regression model developed by Hansen to test the nonlinear relationship between R&D input and firm performance. To illustrate the principle, first consider the single threshold model:

$$Y_{it} = \alpha + \beta_1 X_{it} (q_{it} \leq \gamma) + \beta_2 X_{it} (q_{it} > \gamma) + \theta D_{it} + \varepsilon_{it} \quad (1)$$

In the above model, i represents the company, t is the year; Y_{it} represents the enterprise performance, measured by the return on assets (ROA); X_{it} is the R&D input strength (RD); D_{it} is the set of control variables, including the company size (size), leverage (Lev) and enterprise growth (growth); θ is the coefficient of each control variable; β_1, β_2 respectively indicate the estimated coefficient of R&D input intensity in the first and second threshold intervals; q_{it} represents the threshold variable, ie R&D input intensity, γ represents a specific threshold, α is a constant term and ε_{it} is a random disturbance term.

Let $\beta = (\beta_1, \beta_2)$, $X = X_{it}(\gamma) = \begin{bmatrix} X_{it} * I(q_{it} \leq \gamma) \\ X_{it} * I(q_{it} > \gamma) \end{bmatrix}$, $I(*)$ be an explicit function. When the condition in parentheses is satisfied, the value is 1; otherwise, the value is 0, and further simplified, it can be written as

$$Y = \beta X(\gamma) + \varepsilon \quad (2)$$

Where $\beta = [\beta_1 \beta_2 \theta]$, $X = X_{it}(\gamma)$, for a given arbitrary γ , the least squares estimator of the corresponding coefficient is

$$\hat{\beta} = [X^*(\gamma)' X^*(\gamma)]^{-1} X^*(\gamma)' \times Y \quad (3)$$

The sum of the square of the residual error of the regression equation is

$$SSE_1 = Y^* \left(1 - Y(\gamma) \left(X^*(\gamma)' X^*(\gamma) \right)^{-1} X^*(\gamma)' \right) \times Y \quad (4)$$

The estimated value of the threshold is

$$\hat{\gamma} = \arg \min SSE_1(\gamma) \quad (5)$$

$$\hat{\beta}^2(\hat{\gamma}) = \frac{1}{n(T-1)} \hat{\varepsilon}^*(\hat{\gamma}) \hat{\varepsilon}^*(\hat{\gamma}) = \frac{1}{n(T-1)} SSE_1(\hat{\gamma}) \quad (6)$$

After obtaining the estimated values of the parameters, it is also necessary to test the significance and authenticity of the threshold effect. The null hypothesis and test statistic for a single threshold significance test are as follows:

$$H_0: \beta_1 = \beta_2 \quad F_1 = \frac{SSE_0(\gamma) - SSE_1(\hat{\gamma})}{\hat{\sigma}^2} \quad (7)$$

The likelihood ratio statistic for the corresponding Hansen construction is:

$$LR_1(\gamma) = \frac{SSE_1(\gamma) - SSE_1(\hat{\gamma})}{\hat{\sigma}^2} \quad (8)$$

The distribution of LR statistic is also non-standard. When the gradual distribution is satisfied $LR_1(\gamma) \leq -2\ln(1 - \sqrt{1 - \alpha})$, the null hypothesis is not established, and the confidence interval of the threshold estimator is obtained.

The above is the test and estimation of the single threshold. When F_1 is not significant, accepting the alternative hypothesis requires checking the next threshold, and so on, until the original hypothesis cannot be rejected.

4. Empirical analysis

4.1 Threshold effect test

According to the bootstrap simulation results in Table 1, the double threshold model can be accepted at 5% significance level. The R&D input intensity thresholds were 3.47% and 4.49%, respectively.

Table 1. Threshold effect existence test.

Model	F statistic	P-value
Single threshold	23.47**	0.02
Double threshold	21.33**	0.02
Triple threshold	15.52	0.36

Note: F statistic and P-value are calculated by bootstrap repeated self-sampling 500 times; ** indicates significant at 5% significance level.

4.2 Threshold effect analysis

Further evaluation of each parameter is shown in Table 2. It can be seen from the table that when the R&D input intensity of listed companies in China is lower than 3.47%, it has a significant negative effect on corporate performance. When the R&D input intensity is between 3.47% and 4.49%, it has a significant effect on corporate performance. When the R&D input intensity exceeds 4.49%, it still has a positive impact on corporate performance, but the impact is weakened, which validates the hypothesis of this paper. In terms of control variables, company size and growth have a significant positive impact on firm performance. Financial leverage has a significant negative impact on business performance.

Table 2. Threshold coefficient estimation results.

	β_1	β_2	β_3	size	Lev	growth
Coefficient	-0.23***	0.62***	0.32***	0.62***	-0.05***	0.28***
Standard error	(0.04)	(0.15)	(0.12)	(0.16)	(0.01)	(0.05)

Note: *** indicates significant at 1% significance level.

5. Summary and inspiration

This paper verifies the impact of R&D investment on corporate performance and finds the optimal range of 3.47% to 4.49%. The existence of this interval effect indicates that only the reasonable arrangement of R&D investment can maximize the performance of the company. This requires that the enterprise manager only recognizes the threshold effect relationship between the two, and makes scientific and reasonable decision-making according to the actual situation of the enterprise, in order to make the R&D investment play the role to the greatest extent, help the enterprise to enhance its core competitiveness and improve the performance of the enterprise.

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References

- [1] Martin, Quantile Estimates of the Impact of R&D Intensity on Firm Performance, *Small Business Economics*, vol. 39, pp. 19-37, 2012.
- [2] Zhang Jian and Zhang Linghong, The Impact of R&D Investment on Corporate Performance: Empirical Evidence from Chinese Listed Companies in 2009-2011, *Scientific Decision*, vol. 1, pp. 54-72, 2014.
- [3] Dai Xiaoyong and Cheng Liwei, Research on the Threshold Effect of R&D Investment Intensity on Firm Performance, *Science Research*, vol. 31, pp. 1708-1716+1735, 2013.
- [4] Ye Songqin, Zhu Qingzhen and Ling Fang, Technical Threshold Effect, Scientific Research Input and Enterprise Performance-Based on the Case Analysis of ZTE, *Jiangxi Social Sciences*, vol. 38, pp. 220-226, 2018.
- [5] Hartmann G.C., Myers M. B. and Rosenbloom R.S., Planning your firm's R&D investment, *Research Technology Management*, vol. 49, pp. 25-36, 2006.