Research on the impact of R&D investment on the performance of equipment manufacturing enterprises

Xiangtong Zhao¹*, Zipeng Yu²

¹ Wuhan University of Science and Technology Wu Han, China
² Wuhan University of Science and Technology Wu Han, China
*Corresponding author’s e-mail: yuzipeng@wust.edu.cn

Abstract: R&D investment is a key factor for enterprises to enhance core competitiveness and achieve sustainable development, and also a key factor to improve the performance of equipment manufacturing enterprises. Taking 292 listed companies in equipment manufacturing industry as the research object, this paper explores the impact of R&D investment intensity and R&D personnel ratio on enterprise performance by analyzing the impact of R&D investment intensity and R&D personnel ratio on enterprise performance. The R&D input intensity of Listed Companies in China's equipment manufacturing industry is at a medium level, and their competitiveness is not strong. There is a significant negative correlation between the current R&D input intensity and the current performance of the enterprise. There is a significant positive correlation between the current R&D input intensity and the current business performance of the enterprise. However, there is no significant relationship between the current R&D personnel ratio and the current performance of the enterprise.

1. Introduction

Under the background of the rise of trade protection power between COVID-19 and other countries, the development of China's equipment manufacturing industry is not a small challenge. As the source of improving enterprise productivity, R&D investment is an important way for equipment manufacturing enterprises to meet the challenges and achieve performance growth. Among them, enterprises invest their own resources in R&D to narrow the performance gap with advanced enterprises. In 2019, China invested 2214.36 billion yuan in R&D, an increase of 12.5%. Among them, 786.8 billion yuan was invested in R&D of equipment manufacturing industry, accounting for 56.3% of China's total, with an investment intensity of 2.07%, an increase of 0.16%. From the statistical point of view, China's enterprises occupy the dominant position in R&D investment, and are mainly concentrated in the equipment manufacturing industry, but the investment intensity is only 2.07%. When the input intensity is 2%, the enterprises can only survive, and when the input intensity is 5%, they are competitive, indicating that the R&D investment of China's equipment manufacturing enterprises is still insufficient. Why does this phenomenon still appear in the trend of promoting the upgrading of manufacturing industry in China? Can R&D investment bring about the growth of enterprise profits? This paper analyzes these problems by studying the impact of R&D investment on enterprise performance of equipment manufacturing enterprises.

In terms of foreign research, N. L William³ found that R&D expenditure will have an impact on enterprise performance growth in the next year through the research on the data of American manufacturing industry from 1957 to 1967, and this impact will continue to rise steadily in the next nine
years. K. H Czartizkid conducted an in-depth analysis on the relationship between R&D investment intensity and performance level of high-tech enterprises, and found that there is a nonlinear correlation between them, that is, R&D investment intensity is significantly negatively correlated with current performance level of enterprises, but positively correlated with long-term performance level. Chin and Cheng used the "smile curve" theory to analyze the data of 436 listed companies in Taiwan from 1996 to 2010, and found that R&D investment has a long lag in improving corporate performance.

In terms of domestic research, Zhou Jiangyan takes China's listed manufacturing companies as the research object, and believes that there is a significant positive correlation between the current R&D investment and the current performance of enterprises, but there is a one-year lag. Wang Yiming and Yangmei (2017) used the 3SLS method and simultaneous equations model to explore the data of China's A-share listed companies from 2006 to 2015, and found that the long-term stable R&D investment of enterprises will bring the improvement of performance and market value. Wang Hanyu and Zhu Heping chose the data of 233 listed manufacturing companies in China from 2011 to 2015 as the research object when testing the impact of R&D investment on enterprise performance, and found that the impact of R&D investment on enterprise performance has a lag effect of inverted "V" structure.

Based on the research results at home and abroad, they all focus on the empirical research of specific regions and specific industries. They agree that R&D investment will have a positive impact on enterprise performance, but there are great differences on the number of lag periods. The reason is that different regions and industries have unique characteristics, which will produce certain deviation to the research results. Therefore, this paper takes China's equipment manufacturing industry as the research object to study the effect of R&D investment on performance. At the same time, due to the late development of China's securities industry, the relevant data disclosure is incomplete, which makes the previous research inevitably produce errors. Therefore, this paper selects the data of China's equipment manufacturing enterprises from 2015 to 2019 to reduce the impact of lack of data on the research results.

2. Theoretical analysis and model construction

2.1. Theoretical analysis
Schumpeter's innovation theory points out that in the long-term process of economic progress, the decisive factors are the progress of production technology and the improvement of production mode. As an endogenous factor in the production process of enterprises, innovation is to create a "new combination" of production factors and production conditions, which is introduced into the production system to realize the "new combination" of production factors or production conditions. The so-called "economic development" means that the whole society constantly realizes this "new combination", and the purpose of this "new combination" is to obtain potential benefits Profit, that is to maximize the excess profit. Schumpeter believes that promoting the progress of production technology must be based on innovation. If enterprises want to develop continuously and remain invincible in the fierce market competition, they must focus on continuous innovation and R&D at the technical level. This also tells the key decision-makers of enterprises to realize the importance of technological progress, take technological progress as the cornerstone, create more favorable conditions for enterprises, and promote the development and progress of enterprises. Based on this, this paper puts forward the following hypotheses:

Hypothesis 1: there is a significant correlation between R&D funds and R&D personnel investment and enterprise performance.

Schumpeter's innovation theory points out that technological innovation activities are a complete chain, including resource input, R&D process, achievement output, technology application, performance effect and other links. The resources and time required by each link are subject to the economic development level and resource endowment of different regions and industries. Due to the particularity of the equipment manufacturing industry, the scale of investment is large and the R&D process takes a long time. From the start of R&D project to the success of product development and then to the product launch, enterprises need to provide continuous human and material resources and time investment. At
the same time, China's equipment manufacturing industry started late and developed rapidly, but it is in the middle and lower reaches of the value chain. Compared with the major developed economies, R&D investment has a large gap in scale and time. Therefore, the following hypotheses are put forward:

Hypothesis 2: there is a lag effect between R&D funds and R&D personnel investment and enterprise performance.

2.2. Index definition

2.2.1. Explained variable
The performance of enterprises is mainly measured by profit index, of which the most commonly used profit index is gross operating profit (GMP). The R&D investment of enterprises is mainly through improving the innovation ability of enterprises, designing new products, increasing the income of enterprises, or designing better production process, so as to reduce the cost of enterprises. Therefore, enterprise R&D investment mainly affects the operating revenue and operating costs. In view of the above considerations, this paper uses gross profit margin as an indicator to measure enterprise performance, that is, the explained variable.

The calculation formula is: \( \text{GMP} = \frac{\text{operating revenue} - \text{operating cost}}{\text{operating revenue}}. \)

2.2.2. Explanatory variable
R&D investment is mainly reflected in capital and personnel. Due to the restriction of R&D funds receiving from the enterprise revenue and the restriction of R&D personnel receiving from the total number of employees, this paper uses two indicators of R&D investment intensity (RDSSR) and R&D personnel ratio (RDPR) to measure the level of R&D investment from two aspects of financial and human resources. The calculation formula is as follows:

- R&D investment intensity = R&D expenditure amount / operating income in the current year.
- R&D personnel ratio = number of R&D personnel / total number of in-service employees.

2.2.3. Control variables
As the main factors affecting enterprise performance are capital investment, labor investment and R&D investment, this paper uses the logarithm of net fixed assets (\( \ln\text{NFA} \)) to control the impact of fixed assets investment on enterprise performance. At the same time, the paper introduces earnings per share (\( \text{EPSL} \)) and asset liability ratio (\( \text{ALR} \)) as control variables to control the time series of corporate profitability and the impact of financial leverage on corporate performance.

2.3. Modeling
This paper argues that there is a positive correlation between R&D investment and corporate performance:

\[
\text{GPM}_i = \beta_0 + \beta_1 \text{RDSSR}_{i,j} + \beta_2 \text{RDPR}_{i,j} + \beta_3 \text{EPSL}_i + \beta_4 \ln\text{NFA}_i + \beta_5 \text{ALR}_i + \beta_6 \text{YEAR}1_i + \beta_7 \text{YEAR}2_i + \beta_8 \text{YEAR}3_i + u_i, j = 0,1,2
\]

Among them, \( i \) represents the enterprise, \( t \) represents the year from 2015 to 2019, \( \text{GPM}_i \) represents the gross operating profit rate of the enterprise, \( \text{RDSSR}_{i,j} \) represents the R&D input intensity of the \( i \)th enterprise lagging behind period \( j \), \( \text{RDPR}_{i,j} \) represents the R&D personnel input ratio of the \( i \)th enterprise in year \( j \), \( \ln\text{NFA}_i \) represents the logarithm of the net fixed assets of the enterprise, \( \text{EPSL}_i \) represents the earnings per share of the enterprise in the previous period, and \( \text{ALR}_i \) represents the asset liability ratio of the enterprise. \( \text{YEAR}1, \text{YEAR}2, \text{YEAR}3 \) are nominal variables to control the impact of year difference on performance. \( \beta \) unobservable individual characteristics for the enterprise and \( u \) is the error term.
3. Empirical analysis

3.1. Data description
This paper selects the equipment manufacturing enterprises of A-share listed companies in the stock exchange from 2015 to 2019 as the sample, and the effective number of A-share listed equipment manufacturing companies is 292, with a total of 1460 sample points. The data source is Shenzhen xishima Data Technology Co., Ltd (http://www.csmar.com/Csmar.html).

It can be seen from Table 1 that 57.26% of the sample sites had R&D intensity between 2% and 5% from 2015 to 2019, and 31.23% of the sample sites had R&D intensity greater than 5%. Cheng Hongwei pointed out that only when the R&D expenses account for 2% of the company's sales revenue can the enterprise survive, and only when the R&D expenses reach 5% of the sales revenue can the enterprise be competitive. From the collected sample points, it can be seen that only 11.51% of the enterprises have R&D intensity lower than 2%, indicating that most of the enterprises in China's equipment manufacturing industry pay attention to R&D investment and have certain competitiveness in the market.

| Range                | Number of sample points | Proportion (%) |
|----------------------|-------------------------|----------------|
| R&D intensity < 2%   | 168                     | 11.51          |
| 2% ≤ R&D intensity < 5% | 836            | 57.26          |
| 5% ≤ R&D intensity   | 456                     | 31.23          |
| Total                | 1460                    | 100            |

3.2. Benchmark regression results
The regression results are shown in the table. Table 2 shows the regression results of the fixed effect model of R&D input intensity and R&D personnel ratio on the operating gross profit rate, and considers the lag effect. The logarithm of net fixed assets, earnings per share of the previous period and asset liability ratio are added to each column of regression, and the clustering effect is used to correct the standard error in the regression model. The empirical results show that the coefficient of RDSSR is significantly negative in the regression of the current period and the second lag period, which indicates that the R&D input intensity is negatively correlated with the business gross profit rate in the current period and the second lag period, and the coefficient of RDSSR is significantly positive in the regression of the first lag period, which indicates that the R&D input intensity is positively correlated with the business gross profit rate in the first lag period; the coefficient of RDPR is positively correlated in the current period and the first lag period. It shows that R&D personnel ratio has a positive effect on the business gross profit rate in the second lag period. Based on this, hypothesis one does not hold and hypothesis two holds. At the same time, we can draw the following conclusions: the R&D input intensity of equipment manufacturing industry will have a negative impact on enterprise performance in the current period, a positive impact in the lag period, and a negative impact in the lag period. R&D personnel ratio has a positive impact on enterprise performance in the second lag period, but it is not significant in the current period and the first lag period. The possible reason is that the equipment manufacturing industry is a capital intensive industry, which has a large demand for capital and a fast process update. Therefore, the R&D investment intensity has a positive effect only in one lag period, and the sensitivity to the change of employee input is low, and has a large lag effect.

| Variables        | j=0 Coefficient | j=1 Coefficient | j=2 Coefficient | t-statistic   | t-statistic   | t-statistic   |
|------------------|-----------------|-----------------|-----------------|--------------|--------------|--------------|
| RDSSR_{i-1}      | -9.388**        | 5.137*          | -7.970*         | (-2.57)      | (1.63)       | (-1.71)      |
| RDPR_{i-1}       | -0.694          | 1.560           | 2.706*          | (-0.51)      | (0.71)       | (1.80)       |
| EPSL_{i-1}       | 95.812*         | 112.782*        | 108.963*        | (1.74)       | (1.86)       | (1.67)       |
| ln NFA_{i-1}     | 54.657*         | 207.293         | 268.715         | (1.77)       | (1.56)       | (1.44)       |
| ALR_{i-1}        | -2.498          | -3.212          | -4.108          | (-1.24)      | (-1.32)      | (-1.39)      |
| N                | 1,439           | 1,148           | 860             |

Table 2: benchmark regression results
### 4. Research conclusion

Based on the descriptive statistical analysis of R&D investment intensity and R&D personnel ratio of listed manufacturing companies in China and the regression analysis of the correlation between R&D investment intensity and enterprise performance, this paper draws the following conclusions.

#### 4.1. The R&D investment intensity of Listed Companies in equipment manufacturing industry is at the medium level, but the competitiveness of the companies is not high.

The average R&D input intensity of Listed Companies in equipment manufacturing industry from 2015 to 2019 is 5.45%, indicating that enterprises have certain competitiveness, but the proportion of R&D input intensity below 5% is 68.77%, indicating that most enterprises can maintain their own production, but their competitiveness is weak, which is not conducive to the development of the whole industry. The reason may be that there is a big gap between Chinese enterprises and foreign enterprises in technology level, so they are more willing to choose outsourcing technology and equipment, which makes R&D investment low. And the R&D input intensity is a process of continuous accumulation. Because China's equipment manufacturing industry started late, compared with other international enterprises, the R&D input intensity is low. At the same time, the average intensity of R&D investment is 5.45%, which indicates that the listed companies in China's equipment manufacturing industry are more and more aware of the important role of R&D investment in the cultivation of enterprise's core competitiveness, and gradually realize that R&D investment is the key to improve enterprise's independent innovation ability, and also the key to realize value-added and sustainable development.

#### 4.2. R&D investment and R&D personnel ratio have different effects on enterprise performance, and both have hysteresis.

Through the analysis of regression results, we can see that there is a certain correlation between R&D investment and enterprise performance of Listed Companies in China's equipment manufacturing industry. There is a significant negative correlation between the current R&D investment and the current operating gross profit rate, and there is a significant positive correlation between the R&D investment lagging behind the first and second periods and the current operating gross profit rate, which shows that the R&D investment of Chinese enterprises has a significant impact on enterprise performance, and the impact of different periods of development is different. However, there is no significant correlation between R&D personnel ratio and enterprise performance in the current period and the lag period, but only in the lag period. It shows that compared with R&D personnel, R&D capital is the main factor affecting enterprise performance. The reason for this phenomenon may be that Chinese enterprises pay more attention to applied research, thus ignoring the role of basic research in promoting enterprise value. Enterprises invest more R & D funds in applied research and less R & D funds in basic research, which will inevitably lead to the short-term impact of R & D investment on enterprise performance and the short lag effect period.

### Acknowledgments

Project: Research on the impact of R&D investment on innovation development cycle of small and medium-sized science and technology enterprises in Hubei Province (No. HBSME2019A01)

### Reference

[1] Wang Wei, Jiang zhenmao.(2020) Technology introduction or independent innovation: the choice for backward enterprises to catch up with and surpass performance. Financial development, 02: 17-34
[2] National Bureau of statistics, Ministry of science and technology, Ministry of finance.(2020) Statistics bulletin of national science and technology investment in 2019. Xinhua News Agency, Beijing.

[3] William N.L.(1971) Research and Development in Industrial Growth. The Journal of Politica Economy, 2:5-21

[4] Czarntizkid., K. H. (2004) The Link between R&D Subsidy, R&D Spending and Technological Performance. ZEW Discussion Paper, 4:4-12

[5] Chin-Jung Luan, Chengli Tien. (2015) Should the smiling curve frown during an economic downturn to enhance firm performance? Journal of Management & Organization 21:1-21.

[6] Zhou Jiangyan. (2012) Research on the correlation between R&D investment and enterprise performance -- Based on the empirical analysis of listed manufacturing companies in China. Industrial technology economy, 31: 49-57.

[7] Wang Yiming, Yang Mei. (2017) The relationship between enterprise innovation input, performance and market value -- Based on the data of Chinese Listed Companies. Economic issues, 04: 1-5,32.

[8] Wang Hanyu, Zhu Heping. (2018) Research on the relationship between R&D investment and performance of manufacturing enterprises -- Based on the moderating effect of executive incentive. Financial communication, 17: 28-33.

[9] Wang Ying, Chen Jiaxi. (2018) Measurement of global value chain status of China's equipment manufacturing industry and its sub sectors. Industry economic review, 01: 118-131.