



# Operation Performance Gap and R&D Investment

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**Abstract.** Due to the uncertain environment, actual business results may be significantly lower than expected. Will this affect R&D investment? This study examines the relationship between operating performance gap and R&D investment. We find that the operating performance gap can motivate technology-intensive firms to invest more in R&D, while the effect on non-technology-intensive firms is not significant.

**Keywords:** Performance gap · R&D investment · Technology-intensive

## 1 Introduction

China's economic growth has shifted from the stage of high-speed growth to the stage of high-quality development, and the decisive role of the market in allocating resources has been significantly enhanced. However, the complex and volatile external environments such as the impact of the new crown pneumonia epidemic, the instability of the international situation, and the headwinds of economic globalization have led to a significant decline in the return on investment of enterprises, and the actual operating performance is often lower than the expected target performance. So does the operating performance gap affect corporate R&D investment?

Research on the relationship between operating performance gaps and R&D investment has been explained differently by corporate behavior theory and performance feedback theory. On the one hand, some theoretical studies have linked the operating performance gap to behavioral theories, suggesting that in firms facing financial and operational pressures, management will adopt more conservative strategic behavior and reduce risky innovative activities such as R&D investments (Staw et al., 1981) [1]. On the other hand, many studies argue that when the actual business performance is less than the expected target performance, it will drive the enterprise to explore new solutions, increase risk tolerance, and then adjust the investment strategy (Zellweger et al., 2012; Sanders et al., 2016) [2, 3]. To achieve the long-term business goal of the enterprise, it must continue to innovate (Zellweger et al., 2012) [2]. The greater the gap between the actual and expected performance, the more innovative activities the enterprise engages in (Guan et al., 2020) [4]. These different perspectives suggest that the impact of operating performance gaps on R&D investments is unclear.

To this end, this paper analyzes the relationship between the operating performance gap and R&D investment using a sample of listed companies from 2013–2020. We find that the operating performance gap is associated with increased R&D investment, and the high technology intensive is a stronger effect on R&D than firms with low technology intensive.

## 2 Hypothesis Development

Enterprise behavior theory is one of the important theories to explain the relationship between the performance expectation gap and all kinds of enterprise response behavior. According to the basic logic of the theory, organizations often judge success or failure according to the difference between actual business performance and expected performance (Song, 2015) [5]. When facing a negative operating performance gap, even if the negative operating performance gap is equal to the positive operating performance gap, the decision-makers will react more intensely to the negative operating performance gap (Hu, 2011) [6]. So the operating performance gap will dominate the investment decision-making of enterprises. In addition, when the actual business performance of an enterprise is lower than the expected performance, it means that there are problems in the current business management or business strategy decision-making. Enterprises tend to choose risky decisions such as investment in innovative projects (Li, 2018) [7]. On the one hand, increasing R&D investment in new technologies or new products is the main way for enterprises to achieve technological leadership or open up new markets, which can improve the core competitiveness of enterprises, expand market share, and improve business performance. On the other hand, enterprises can obtain unique technologies or new products through R&D investment. The technological innovation achievements are difficult to replicate so that firms can obtain market excess returns. In one word, seeing from the long-term development of enterprises, the negative operating performance gap is greater, and the motivation for R&D investment is stronger.

In addition, enterprise decision-making behavior is influenced by managers' cognitive ability, perception ability, and other factors. The expected performance level of enterprises is the "minimum satisfactory result" which is accepted and recognized by managers (Li, 2018) [7]. However, when the actual business performance of an enterprise is lower than the expected performance, it will be perceived as a decision-making "failure" by bounded rational managers (Desai, 2008) [8], which drives managers to re-examine the current investment decisions, thereby finding new strategic solutions and solve the current difficulties. For this reason, managers' risk tolerance increases, and they often show the pursuit of risk-taking and change strategic decision-making behavior to try to improve their performance, such as the decision-making behavior of high-risk innovation. In addition, with the increase in the negative operating performance gap, managers' status and reputation will also be threatened, so the pressure to reverse the current performance dilemma will double. To maintain and consolidate professional reputation and status, managers tend to choose R&D investment with higher risk when the actual business performance is lower than the expected performance. Therefore, based on the analysis of long-term development and managers' factors, we state our second hypothesis in the null form:

Hypothesis 1: The greater the difference between the actual operating and expected performance, the more R&D investment the enterprise will be.

The technology-intensive degree is often used as an important indicator to measure the technological level and R&D capability of enterprises. There are differences in the technology intensity of enterprises, and the reflection of the business performance gap and R&D investment decisions will also be different. Compared with low-tech-intensive enterprises, high-tech-intensive enterprises have more conditions and motivation to engage in innovation activities when the actual business performance is lower than expected. Because high-tech-intensive enterprises have a good R&D foundation, there are also advantages in the innovation dynamics of products and services. Therefore, when there is a gap in business performance, enterprises are more motivated to develop new technologies or new products to maintain competitive advantages or open up new markets. Based on the above theoretical analysis, we state our third hypothesis in the null form:

Hypothesis 2: Compared with non-technology intensive enterprises, technology-intensive-enterprises have more motivation and ability to increase R&D investment when the actual operating performance is lower than the expected performance.

### 2.1 Sample Selection

The study period started in 2010 because the sample includes a large number of GEM-listed companies, GEM-listed companies began in 2009. The study period ended in 2018, due to COVID-19, operating performance gaps are common after 2019. In addition, we exclude Eliminate ST and PT samples, excluding financial institutions and the real estate industry, and exclude the samples with missing expected operating and other financial data. The final sample includes 8848 firm-year observations for the 2010–2019 period. All continuous variables are winsorized at the 1st and 99th percentiles to mitigate the potential effect of outliers. The original data of enterprises come from the CSMAR database.

### 2.2 Empirical Models

To test Hypothesis 1, which states that the greater the difference between the actual operating and expected performance, the more R&D investment the enterprise will be. We utilize the following ordinary least squares (OLS) regression model:

$$RD_{i,t} = \alpha + \beta_1 * RD_{i,t-1} + \beta_2 * dprofit_{i,t-1} + \gamma * Controls_{i,t} + \varepsilon_{i,t} \quad (1)$$

The dependent variable  $dprofit_{i,t}$  is the difference in operating performance of enterprise  $i$  in  $t$  year, which is measured by using  $\ln|I*(fprofit_{i,t} - pprofit_{i,t})|$   $fprofit_{i,t}$  is the total actual operating profit of the enterprise, and  $pprofit_{i,t}$  is the total expected profit of the enterprise. If  $fprofit_{i,t} - pprofit_{i,t} < 0$  means that the actual operating performance of the enterprise is lower than the expected performance, it is defined as  $I = 1$ , otherwise it is 0. Lagged operating performance gap ( $dprofit_{i,t-1}$ ) is used in Eq. (1), because we analyze the influence of the operating performance gap on the subsequent decision-making behavior (Li, 2018) [7].

Grouping variable: Technology intensity. According to the guidelines for industry classification of listed companies announced by CSRC [2012] No.31, excluding the financial industry and real estate industry. Enterprises are divided into two categories: technology-intensive and non-technology intensive. Technology-intensive industries include computer, communication, and other electronic equipment manufacturing, machinery, equipment, instruments, medicine, biological products, other manufacturing industries, information technology industries, etc. Other remaining industries are classified as non-technology-intensive industries.

### 3 Empirical Results

#### 3.1 Descriptive Statistics

Panel A of Table 1 reports the descriptive statistics for the full sample. The mean (median) value of RD is 0.0645 (0.0413), and the R&D investment is 6.45% of sales. However, the maximum and minimum values of RD are 0.4678 and 0.004, and the median is less than the mean, indicating that there is a big difference in R&D investment among enterprises. There are 2657 samples of the operating performance gap, which shows that the actual operating performance of most enterprises has reached the expected performance target.

Panel B of Table 1 compares the descriptive statistics of variables between technology-intensive firms and non-technology-intensive firms. The mean value of RD for technology-intensive(non-technology-intensive) firms is 0.0706 (0.0430), and the mean values of RD of technology-intensive firms are significantly higher than this for non-technology intensive.

#### 3.2 Main Results

Table 2 reports the results of estimating Eq. (1) to examine Hypothesis 1 and Hypothesis 2. We report the results for the full sample, the coefficient on Dprofit, which represents

**Table 1.** Descriptive statistics (Self-drawn)

Panel A					
Variable	Mean	Std. Dev.	Min	median	max
RD	0.0645	0.0756	0.0004	0.0413	0.4678
Dprofit	17.0562	2.0694	11.5495	17.1143	21.6916
Panel B					
	Technology-intensive sample		Non-technology intensive sample		t-test
Variable	n	Mean	n	Mean	
RD	6921	0.0706	1927	0.0430	-14.3087***
Dprofit	1877	16.8809	780	17.4782	6.8331***

Note: \*, \*\*, and \*\*\* indicate significant at the 10%, 5% and 1% levels, respectively.

**Table 2.** Regression results (Self-drawn)

	Total sample		Technology-intensive sample		Non-technology-intensive sample	
	Coefficient	t	Coefficient	t	Coefficient	t
Dprofit	0.0003**	2.44	0.0003**	2.39	0.0002	1.06
RD <sub>i, t-1</sub>	0.624***	29.97	0.658***	29.36	0.413***	8.27
Growth	-0.0036	-1.17	-0.0076**	-2.17	0.0083	1.25
Lev	-0.0267***	-5.66	-0.0255***	-4.40	-0.0166**	-2.13
Cf	-0.0275**	-2.37	-0.0312**	-2.26	-0.0013	-0.06
Q	0.0049***	5.67	0.0050***	5.53	0.0040	1.44
Size	0.0012	1.36	0.0025**	2.19	-0.0018	-1.09
Age	-0.0032*	-1.69	-0.0001	-0.04	-0.0126***	-2.57
_ cons	0.0145	0.75	-0.0367	-1.40	0.107**	2.52
n	7348	5742	1606			
Adj. R-sq	0.431	0.461	0.237			

Note: \*\*\*, \*\*, and \* indicate significant levels at 1%, 5%, and 10%, respectively.

the relation between RD and Dprofit is positive and significant (0.0003;  $t = 2.44$ ). This finding suggests that the larger the operating performance gap, the more R&D investment. Collectively, this evidence rejects null Hypothesis 1. This also shows that when the actual operating performance is lower than the expected operating performance, to find new performance growth points, the management of enterprises will increase the investment in projects with higher risks, and enhance the competitiveness and operating performance.

We report the results for technology-intensive and non-technology-intensive. In technology-intensive the coefficient on Dprofit, which represents the relation between RD and Dprofit is positive and significant (0.0003;  $t = 2.39$ ). In non-technology intensive the coefficient on Dprofit, which represents the relation between RD and Dprofit is positive and non-significant (0.0002;  $t = 1.06$ ). This result means that when there is an operating performance gap, technology-intensive firms tend to increase R&D investment, while non-technology-intensive firms will not seek new development opportunities through R&D investment.

### 3.3 Robustness Check

Table 3 reports the results of estimating after substitution of Dprofit variable. Dprofit is measured using the return on assets (roa), when the difference between the actual value of Roa minus the predicted value is negative, Dprofit is 1, otherwise, the variable is 0.

In full sample, the coefficient on Dprofit indicates that enterprises will increase R&D investment when the operating performance gap occurs, that is, Hypothesis 1 is

**Table 3.** Robustness checks (Self-drawn)

	full sample		Technology-intensive sample		Non-technology-intensive sample	
	Coefficient	t	Coefficient	t	Coefficient	t
$RD_{i,t-1}$	0.625***	60.62	0.609***	51.46	0.299***	10.61
DProfit	0.0127***	4.69	0.0183***	5.90	0.0001	0.01

Note: \*\*\*, \*\*, and \* indicate significant levels at 1%, 5%, and 10%, respectively.

supported. The coefficient on Dprofit is positive and significant in technology-intensive samples, however, is negative and non-significant in non-technology-intensive samples. When the operating performance of technology-intensive enterprises does not reach the expected performance, enterprises will increase R&D investment, but it is not affected in non-technology-intensive samples. This finding suggests that enterprises with different technology-intensive degrees show different investment decision-making behaviors.

## 4 Conclusion

In the context of innovation-driven strategy, more and more enterprises focus on R&D investment to enhance their competitiveness. However, the actual operating performance of enterprises is often lower than predictions due to the influence of uncertain factors in the external environment. However, little is known about the correlation between the operating performance gap and RD.

Thus, this paper examines the relationship between operating performance gap and R&D investment using A-share listed companies from 2013–2020 as the research sample. The following conclusions are drawn: when companies experience operating performance gap, they will increase R&D investment in order to reverse the unfavorable performance through innovation investment. Operating performance gap and R&D investment have a significant positive relationship in technology-intensive companies, while this relationship is not significant in non-technology-intensive companies.

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