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## The impacts of R&D expenditure and personnel investment on innovation performance: the moderating effects of employee motivation

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### ABSTRACT

The study chose 418 firms from an enterprises database whose data was reported and assessed by the Enterprise Technology Center of Guangdong Province. This study has investigated the impact of R&D capital intensity and R&D personnel intensity on innovative performance, and it has also explored the moderating effects of R&D personnel compensation incentive and R&D personnel training in the relationship above. The result shows that R&D capital intensity and R&D personnel intensity have significant positive effects on innovative performance; R&D personnel compensation incentive significantly moderates the relationship between R&D personnel intensity and innovative performance; R&D personnel training significantly moderate the relationship between R&D capital intensity and innovative performance. However, R&D personnel compensation incentive doesn't significantly moderate the relationship between R&D capital intensity and innovative performance, and R&D personnel training doesn't moderates the relationship between R&D personnel intensity and innovative performance.

### KEYWORDS

R&D investment; Compensation incentive; R&D personnel training; Innovation performance; Moderating effects.



## INTRODUCTION

Technological innovation has been the driving force of the country's economic development, as well as the key for the enterprises to survive and develop sustainably<sup>[1]</sup>. In recent years, the increase in the scale and intensity of China's R & D investment is driving the companies' R & D investment. According to the National Science and Technology Funding Statistical Bulletin, the R & D expenditures in 2012 is 1.03 trillion Yuan, accounting for 1.98% of GDP, including funds from companies which accounted for 76.2%. Obviously, enterprises have become the main investor of R&D. However, the problem about China's insufficiency in independent innovation ability remains serious. Whether the rise in R & D investment could improve R & D capacity dramatically? At present, domestic or international researches could not draw a consistent conclusion on the relationship between R & D investment and innovation output. One view is that the R & D investment and innovation output are significantly and positively correlated<sup>[2-5]</sup>, while another view is that the relationship between R & D investment and innovation output is not significantly or even negatively correlated<sup>[6]</sup>.

After analysis, we consider that the main reason for this inconsistency include: (1) Differences in measuring the R & D investment and innovation output, the measurement of R & D investment includes the absolute index (the amount of fund and the number of staff) and relative indicators (intensity), and the measurement of innovation output including productivity, profitability, other business performance, the number of authorized patents and new product sales revenue and other innovation performance. (2) Differences in sample characteristics. These enterprises are from different countries, regions, industries, while the studies around the comparative between regions and industries are a few. (3) R & D investment is just one of the important elements affecting innovation output, and there are other vital factors that are not included in the analysis, such as the incentives for R & D personnel and so on.

So, we can come to a conclusion that the relationships between R&D investment and innovation output need to be further discussed, meanwhile, there are many issues that need further analysis. Is corporate investment in R & D expenditure and personnel helpful for increasing their innovation performance? Is compensation incentive and training for R & D staffs are helpful for enhancing the degree of the impacts of the R&D investment on enterprises' innovation performance? In order to answer these questions, this paper has investigated the impact of R&D capital intensity and R&D personnel intensity on innovative performance, and it has also explored the moderating effects of R&D personnel compensation incentive and R&D personnel training in the relationship above. Not only has this study enriched the theories in areas of the R & D investment and personnel incentives, but it plays a vital role in guiding enterprises as well, such as: how to invest R & D funds or personnel rationally, paying attention on training staffs and compensation incentives, and how to enhance enterprises' innovation performance.

## THEORETICAL FOUNDATION AND HYPOTHESES

### The impact of R & D investment on innovation performance

Many scholars, overseas or domestic, have studied the empirical research about the relationship between R&D investment and innovation output. The R & D investment generally includes the investment in R&D expenditures and R&D staff input. However, researchers mainly focus on the former but pay relatively little attention to R&D personnel input. Innovation output, on one hand, is a general business performance, which mainly evaluated from aspects such as: productivity<sup>[6,7]</sup>, margins<sup>[5,6]</sup>, the enterprise market value<sup>[8,9]</sup>, the stock price or remuneration<sup>[18]</sup> and so on. On the other hand, it is the innovation performance of enterprises<sup>[2,4]</sup>, mainly assessed from number of authorized patents, new product sales income and so on. Despite the multiple researches on exploring the relationship between R&D investment and innovation output, studies focusing on relationships between innovation investment and performance are rare.

Most of the existing researches show that R & D investment and innovation performance were significantly and positively correlated, but there are also some researchers have made inconsistent conclusions. Scherer's researches show that firms' R&D funds have significant and positive impacts on patent output, though there is a certain lag effect<sup>[2]</sup>. Ren Xiang found that both the R&D personnel and capital investment have considerable and positive influences on technological innovations, but the former's effects are much greater<sup>[3]</sup>. Garner's research found that the rate of innovation is an important factor affecting the market value of the enterprise, while corporate R & D investment will affect the rate of innovation<sup>[4]</sup>. Guan Jiancheng and Shi Xiaomin's empirical analysis shows that in seven genres of technological innovation capability, R&D capability is the most critical factor influencing innovation performance, and it depends on R&D investment<sup>[1]</sup>. Gu Suishan draw a conclusion that : Compared with the R & D funds, the personnel input plays a more significant role in promoting the development of high-tech industry, which emphasized the economic contribution made by the scientific knowledge application and the development of human resources<sup>[10]</sup>. Liang Laixin and Zhang Huanfeng found that the corporation's R & D intensity, firm's ability to innovate, profitability and development capability were significantly and positively correlated<sup>[5]</sup>. However, Feng Wenna found a significant positive correlation between the innovation performance and R & D funds investment. The intensity of R & D capital investment and that of staff input are also significantly positive related, while the correlation between the R & D personnel input and innovation output did not pass the significance test, which has a slight negative correlation with the innovation performance. This is mainly because the excessive R & D personnel input will result in management problems which lead to the decrease of marginal benefit<sup>[11]</sup>.

Based on analysis on both domestic and overseas literatures, we made hypotheses as follows: H1: The R&D capital intensity has significant positive effects on innovation performance H2: The R&D personnel intensity has significant positive effects on

innovation performance

### The moderating effects of R&D personnel incentive

R & D investment is the key to enhance the technological innovation capability and innovation performance of enterprises. The employees, especially R & D staffs, are the most important resource in enterprises. They are also the core factors of production and the foundation of corporate survival and development<sup>[12,13]</sup>. When enterprises increase the R & D investment, they must strengthen the incentive for R & D personnel and guide them to full play their initiative, so as to maximize the role of R & D investment. Pan Yinwen and Wan Difang believe that there are uncertainties among R&D activities, which is resulted from both external environment and internal technical characteristics. So, the incentives for R&D subject, which is actually the R&D staffs, become more important, and it is also the core for companies to continue to innovate, or to maintain their competitive advantages<sup>[13]</sup>. Li Weidong, etc. pointed out that the compensation incentive is the most important measurement for motivating R & D personnel, and it includes external and internal salaries which are complement<sup>[14]</sup>. Effective training can improve their quality and capacity and enable them to undertake more challenging works, so as to meet their self-realization.

In empirical study, Baldwin pointed out that the surveyed enterprises, which are required to provide training, mostly apply at least five new technologies. Enterprises that provide specific training among those who use existing technology for innovation reached 55%, while among those who process innovation depend on the invention of new technology occupied 79%. Therefore, it is clear that trainings, especially special trainings for R&D staffs, play an vital role in enterprises' innovation<sup>[15]</sup>. Laursen used 726 companies in Denmark as research samples. His studies have shown that using a variety of human resource management practices is more effective than using a single one in enhancing employees' innovation performance<sup>[16]</sup>. Qin Xiaolei, etc. drew on 122 manufacturing companies in Shanghai, Jiangsu and Guangdong as samples. Her studies found that both corporate innovation strategies and employee training are significantly and positively correlated to business performance, while the moderating impacts of employee training on innovation strategy and corporate performance is not significant<sup>[17]</sup>. He Huitao and Peng Jisheng's researches suggested that human resource management practices affect knowledge sharing and organizational learning through behavior-oriented, and affect organizational learning capacity through capacity-oriented, and affect innovation performance eventually<sup>[18]</sup>.

Based on analysis of domestic and overseas literatures, we made hypotheses as follows:

H3: R & D personnel compensation incentive significantly moderate the impact of R & D expenditure on innovation performance. H4: R & D personnel compensation incentive significantly moderate the impact of R & D personnel investment on innovation

H5: R & D personnel training significantly moderate the impact of R & D expenditure on innovation performance.

H6: R & D personnel training significantly moderate the impact of R & D personnel investment on innovation performance

## RESEARCH DESIGN

### The samples

Samples of this study came from an enterprises database whose data is reported and assessed by the Enterprise Technology Center of Guangdong Province. The database includes 418 companies which are from electronics, machinery, pharmaceuticals, chemicals, non-ferrous metals, light, public utilities, construction, mining industries and so on, more than 10 industries. According to the reporting requirements, enterprises that tend to join the Enterprise Technology Center of Guangdong Province should have funded expenditures for science and technology activities no less than six million Yuan, and it accounted for the proportion of sales revenue should not less than 3%. Also, the number of full-time R&D staffs should not less than 50, and technology development instruments and equipment at cost should not less than 5 million. As a result, these companies generally have better R&D and testing conditions, possess the core technology of independent intellectual property rights, and their level of R & D and innovation are on a leading position in the industry. Also, the materials reported must be reviewed and stamped official seal by the same level of various cities' economic and trade departments, the IRS, the Local Revenue Department and the local customs, which ensured the accuracy and authenticity of the data.

TABLE 1: Measurement of variables

Variables	Measurement
R&D capital intensity	R&D expenditures/ the sales revenue
R&D personnel intensity	Number of staffs in technology center/ total number of that in enterprise
R&D compensation incentive	Per capita income in technology center / per capita income in enterprise
R&D personnel training	Per training expense / Per capita income in technology center
Innovation performance	The sales revenue of new products/ the total sales revenue

### Research variables and measurement

This study mainly investigated the impact of R&D investment and personnel incentive on innovation performance. R&D investment includes the R&D capital and R&D staff input, while personnel incentive includes compensation incentive

and personnel training. By contrast, innovation performance is mainly focus on the sales revenues of new products. Owing to the differences, such as which industry and region do these firms come from or their size and characteristics, it is difficult to compare the absolute number of these variables, therefore, in this study the relative number (i.e. intensity) were used as measurements (see TABLE 1). Meanwhile, the relative numbers were standardized processed according to their respective industries before the correlation and regression analysis.

**RESULTS AND DISCUSSIONS**

Before doing the regression analysis, we simply described the non-standardized variables such as: innovation performance, R&D capital intensity, R&D personnel intensity, R&D compensation incentives, R&D personnel training and so on. As a result we got the mean and standard deviation of each of these (see TABLE 2). Then, after the standardization of these variables according to various industries, the correlation matrix was calculated (see TABLE 2).

**TABLE 2: The mean, standard deviation of variables correlation matrix**

Variables	Mean	S.D.	1	2	3	4	5
1 Innovation performance	0.469	0.2515	1.000				
2 R&D capital intensity	0.042	0.0368	0.304***	1.000			
3 R&D personnel intensity	0.141	0.0875	0.238***	0.291***	1.000		
4 R&D compensation incentive	1.896	1.5280	0.213***	0.178**	0.131*	1.000	
5 R&D personnel training	0.272	0.3874	0.189**	0.261***	0.248***	0.145*	1.000

Note: \* P<0.05, \*\* P<0.01, \*\*\* P<0.001

According to the suggestion given by Aiken, West<sup>[19]</sup> and Wen Zhonglin, Hou Jietai and Zhang Lei<sup>[20]</sup>, the independent variable, dependent variable and moderating variable were standardized transformed before the regression analysis. The hypotheses were tested in three steps: the first step, the independent variables enter regression model; the second step, the independent variables, and moderating variables enter the model at the same time; the third step, the independent variables, moderating variables, and the their product also enters the model.

As it was shown in TABLE 3, the first step, model M1 tested the effects of both R&D capital intensity and R&D personnel intensity on the innovation performance. And then the second and third step tested the moderating effects of R & D compensation incentive (model M2a and M3a) and R & D personnel training (model M2b and M3b) respectively. The model M1 shows that the regression coefficient of R&D capital intensity and that of R&D personnel intensity were 0.332 (P<0.001) and 0.242 (P<0.001), which explains the 15.5% variation in innovation performance. Therefore, the R&D capital intensity and R&D personnel intensity affect the innovation performance significantly and positively, which assumes that H1 and H2 were supported.

The model M1, M2a and M3a (see TABLE 3) show that R & D personnel compensation incentive significantly moderates the impact of R & D personnel intensity on enterprises' innovation performance, as the regression coefficient of product is 0.066 which is a significant one (P<0.05). However, the moderating effect of R&D personnel compensation incentive on the relationship between R&D capital intensity and innovation performance is not significant, as the regression coefficient of product is 0.023 and is not significant (P>0.05). Therefore, H4 is supported, while H3 is not.

Model M1, M2b and M3b (see TABLE 3) showed that R & D personnel training significantly moderates the effect of R&D capital intensity on enterprises' innovation performance, as the regression coefficient of product is 0.054 which is a significant one (P<0.05). However, the moderating effect of R & D personnel training on R&D personnel intensity and enterprises' innovation performance is not significant, as the regression coefficient of product is 0.011 and is not significant (P>0.05). Therefore, H5 was supported, while the H6 was not.

Then, in order to further analyze the regulation effects of H4 and H5, moderating effect diagram was drawn according to Aiken & West's suggestions and methods<sup>[19]</sup>. Using the mean of R & D personnel intensity plus and minus one standard deviation and also use the mean of R & D personnel compensation incentive plus and minus one standard deviation, we got four combinations. After subjecting these four charts into regression equations formed by non-standardized coefficient respectively, we got four ends' value. Then, Figure 1 was drawn. It can be seen from Figure 1 that R & D personnel compensation incentive has moderated the influence of the of R&D personnel intensity on enterprise innovation performance. When the compensation incentive is high, the positive effect of R&D personnel intensity on innovation performance is more significant, and higher innovation performance can be brought to the enterprises at the same time. Additionally, it can be seen from Figure 1 that R & D personnel training moderated the impact of R & D capital intensity on the enterprises' innovation performance. When the personnel training is high, the positive effect of R & D capital intensity on innovation performance is more significant, and higher innovation performance can be brought to the firms at the same time.

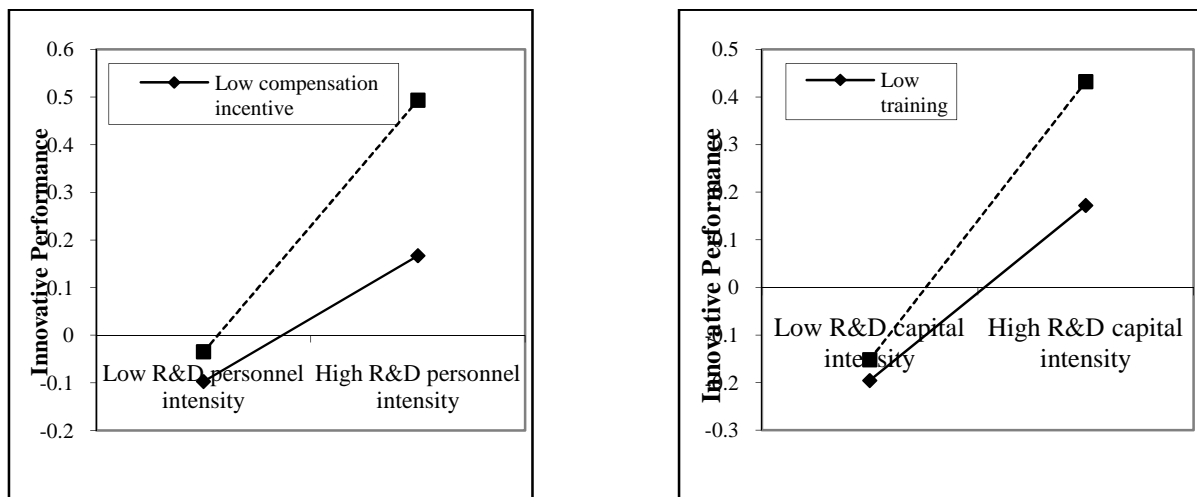
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**TABLE 3: The results of hierarchical regression analysis**

	Dependent variable: Innovation Performance				
	First step M1	Second step M2a	M2b	Third step M3a	M3b
Constant	0.126***	0.157***	0.052***	0.132***	0.064***
Independent variables					
R&D capital intensity (A)	0.332***	0.309***	0.287***	0.287***	0.238***
R&D personnel intensity (B)	0.242***	0.213***	0.132***	0.198***	0.176***
Moderator variables					
R&D compensation incentive (C)		0.106***		0.097***	
R&D personnel training (D)			0.089***		0.076***
The product term					
A × C				0.023	
B × C				0.066*	
A × D					0.054*
B × D					0.011
R <sup>2</sup>	0.155	0.247	0.193	0.293	0.230
The F values of model	22.211***	13.343***	9.576***	17.213***	15.357***
ΔR <sup>2</sup>		0.092	0.038	0.046	0.037
The F values of ΔR <sup>2</sup>		11.604***	8.332***	3.506*	2.848*

Note: \* P<0.05, \*\*P<0.01, \*\*\*P<0.001



**Figure 1 : The maps of moderating effects**

### CONCLUSIONS AND SUGGESTIONS

The empirical results show that the hypothesis 1, 2, 4 and 5 are supported, but 3 and 6 are not. And the conclusions are: (1) R&D capital intensity has a significant and positive effect on innovation performance; (2) R&D personnel compensation incentive significantly moderates the relationship between innovation performance and R&D personnel intensity; (3) R&D personnel training significantly moderates the impact of R&D capital intensity on innovation

performance. However, R&D compensation incentive fails to moderate the effects of R&D capital intensity and innovation performance significantly; R&D personnel training fails to moderate the effects of R&D personnel intensity on innovation performance either.

The contribution of this paper is that we found both R&D capital intensity and R&D personnel intensity are helpful for improving the enterprises' innovation performance through the empirical analysis. What is more, we also found the moderating effects of R&D personnel compensation incentive on the relationship between R&D personnel intensity and innovation performance, and the moderating impacts of R&D personnel training on the relationship between R&D capital intensity and innovation performance. Not only will the study's conclusions enrich the associated theory of R&D investment and personnel motivation, but can provide the theoretical basis for making technology innovation decision of the enterprises in our country as well. It shows an important and practical significance on guiding enterprises to invest in innovation and R&D staffs rationally, paying attention to R&D personnel compensation incentive and training, and improving the innovation performance.

The management implications are mainly reflected in: (1) increasing R&D investment (including capital and personnel) is the foundation and guarantee of enterprises' innovation performance. Innovation will almost be impossible if the R&D personnel and funds investment are not provided, which make the enterprises difficult to obtain the sustainable competitive advantages through innovation. (2) In addition to increase R&D investment, R&D personnel incentive must be paid attention to (including compensation incentive and personnel training). This paper found that motivation is a key factor that influences innovation performance. In addition, compensation incentive and personnel training moderate the impact of R&D input factors on innovation performance in different situations. Obviously, compensation incentive and personnel training can motivate the initiative of R&D staffs, which makes the R&D funds and equipment can be fully utilized.

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