ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

The Complementary Effect of R&D Investment and Human Capital on Enterprise Innovation Performance

Yimin Gu[1, a]

[1]College of Economics, Jinan University, Guangzhou, 510000, China

[a]guyimin1@163.com

Abstract

As an important subject of technological innovation, the R&D activities of enterprises are characterized by complexity, risk, and high cost. The entire process requires the coordination of multiple production factors. Starting from the two elements of capital and manpower, this paper studies whether the company's innovation performance will be affected by the interaction of R&D investment and human capital. This paper constructs a two-way fixed-effect model, using the detailed classification data of R&D investment, employment structure and patent data of listed companies from 2010 to 2019 to test the relationship between R&D investment, human capital and corporate innovation performance. The results show that the increase in R&D investment has significantly improved the innovation performance of enterprises, no matter in absolute or relative amount. The level of human capital of an enterprise is measured by the level of academic qualifications and technology, and it is found that the improvement of human capital has significantly improved the innovation performance of the enterprise. In addition, this article further finds that R&D investment and human capital have complementary effects on corporate performance innovation, and the combination of the two elements has an additional role in promoting corporate innovation. Finally, this paper also studies the heterogeneity of complementary effects, and finds that the complementary effects of R&D investment and human capital have certain heterogeneity in the types of industrial technology and the types of enterprise factor endowments. The research in this paper verifies the "complementary effect" of capital and skilled labor from the micro-enterprise perspective, and puts forward suggestions that enterprises need to allocate factor resources reasonably and optimize resource utilization efficiency in order to improve enterprise innovation performance.

Keywords

R&D investment; Human capital; Complementary effects; Innovation performance.

1. INTRODUCTION

R&D investment is the capital supply of corporate R&D activities, and the impact of corporate innovation performance is self-evident. The research of Sun Hui and Wang Hui (2017) shows that there is a significant positive correlation between R&D investment and new product innovation performance. There are also many scholars who have studied the heterogeneity of the impact of R&D investment on enterprise innovation, and Xie Xuemei et al. (2013) found “Due to regional differences, the effects of R&D investment on innovation performance in the eastern, central and western regions are different”. Qiu Yunjie and Wei Wei's (2016) research found that R&D investment has different effects on corporate performance in corporate ownership. Due to the characteristics of the externality of innovation benefits, the indivisibility of the innovation process, and the uncertainty of innovation results, technology upgrades and

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

R&D There is "market failure" in the innovation process. In order to consolidate the status of high-tech enterprises as the main body of innovation and enhance the R&D investment capacity of enterprises, Arrow (1962) believes that government intervention in enterprise innovation is necessary. Government intervention is mainly finance, taxation and Financial and other preferential policies are provided, so some scholars use R&D investment as a medium for external policies to affect corporate innovation, and study whether R&D investment is used as a policy transmission intermediary. For example, Li Weian (2016) believes that R&D investment is an intermediary variable that links tax incentives and R&D innovation performance.

Human capital is an important source of wealth accumulation in a country. However, according to data released by the World Bank, in 2010, the proportion of the 25-64-year-old population in China with higher education was only about 10%, while the average level in developed countries such as OECD has exceeded 30%, there is still a big gap in the level of human capital between China and developed countries. Heckman (2005) believes that China has a long-standing problem of "heavy material capital and light human capital", which has also led to low overall supply efficiency and "sea rush" phenomena. Technological innovation puts forward higher requirements for the complementarity of capital and skilled workers. China urgently needs to improve corporate human capital, make full use of the coordination and complementarity between physical capital and human capital, and increase the productivity of the two factors of production, thereby forming a high level of productivity. Efficient, high-quality supply.

This paper uses the R&D investment, employment structure detailed classification data and patent data of listed companies from 2010 to 2019 to construct a two-way fixed effect and examine the relationship between R&D investment, human capital and corporate innovation performance. This article aims to deeply study the complementary effects of R&D investment and human capital on enterprise innovation, and to confirm the existence of capital-skill complementarity, which helps to understand the path and mechanism of the coordinated upgrade of enterprise material capital and human capital, and then to effectively Provide suggestions for improving the innovation performance of enterprises.

2. LITERATURE REVIEW

At present, there is a large amount of literature researching the impact of R&D investment on enterprise innovation performance, but there is no unified conclusion. Most scholars believe that there is a significant positive relationship between R&D investment and corporate innovation performance. Scherer (1965) established a linear regression model based on the data of the top 500 companies in the United States, and regarded company size and market power as key variables affecting company innovation performance, and concluded that R&D investment has a significant positive effect on company performance. Bronwyn et al (2013) established a CDM model based on data from Italian manufacturing companies. The study found that increasing R&D investment and communication technology investment has a positive effect on the improvement of innovation output. Gong Yifei et al. (2017) took Shanghai and Shenzhen A-share listed companies as the object and found that the increase in R&D investment has a significant role in promoting corporate performance, and internal control positively regulates the relationship between R&D investment and corporate performance. However, some scholars believe that there is no detailed relationship between the two, and even shows a negative correlation in some cases. Luo Jia et al. (2018) research on listed manufacturing companies found that R&D personnel investment has no significant impact on innovation performance. Feng Wenna (2010) used high-tech enterprises in Shandong Province as the research object, and concluded through regression models that there is a weak negative correlation between R&D personnel investment and enterprise innovation performance. She believes that excessive

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

R&D personnel investment will cause internal consumption of human capital. At the same time, the dilution of research and development funds will ultimately not have a positive effect on patent output. In addition, Kang Zhiyong (2013) found that there is an inverted U-shaped relationship between the intensity of R&D expenditures and the innovation performance of enterprises. He believes that enterprises need to find appropriate investment based on their own actual conditions. Blind and excessive investment cannot achieve innovation performance. Maximize. Similarly, Kim (2020) conducted research on company sub-sectors in 14 countries and concluded that there is an inverted U-shaped relationship between R&D investment intensity and innovation performance.

Talents are an important support for enterprise R&D and innovation. Therefore, enterprises should increase their investment in talents, especially high-skilled talents who have received higher education and have high-level innovative R&D capabilities. Salazar (2006) studied the impact of corporate managers' enthusiasm on corporate innovation performance. Chen and Huang (2009) examined the role of knowledge management capabilities in the relationship between strategic human resource practice and innovation performance. The research results prove that knowledge management ability plays an intermediary role between strategic human resource practice and innovation performance.

Throughout the existing research, there are few literature studies that combine R&D investment with human capital to study their complementary effects on corporate innovation performance. Most of the literature attempts to introduce the role of human capital in corporate innovation from the mediation effect. This article attempts to verify the “complementary effect” of material capital and skilled labor from the perspective of micro-enterprises’ R&D investment and employment results. The research conclusions are helpful to understand the relationship between tax incentive policies and the upgrading of corporate human capital, which helps to understand the relationship between corporate physical capital and The path and mechanism of the coordinated upgrade of human capital can provide effective suggestions for improving the innovation performance of the enterprise.

3. RESEARCH PATH AND RESEARCH HYPOTHESIS

3.1. Research Path

From the micro perspective of the enterprise, this article explores the complementary effects of R&D investment and human capital on enterprise innovation performance. The specific research is divided into three parts. The first is to test whether the company's R&D investment and human capital alone have a significant impact on the company's innovation performance. On this basis, construct the interaction terms of enterprise R&D investment and human capital, and test the complementary effects of the two on enterprise innovation performance. Finally, this article examines the heterogeneity of complementary effects from the level of industrial characteristics and enterprise endowment types.

3.2. Research Hypothesis

The entire R&D activities of an enterprise need to invest a lot of resources, and R&D investment, as a direct capital investment in R&D activities, is crucial to the performance and even the results of the R&D of the enterprise. Based on the analysis of the existing literature on the relationship between the level of R&D investment and innovation performance, this article believes that the level of R&D investment has an impact on innovation performance, so the following research hypothesis 1:

Hypothesis H1: Enterprise R&D investment is an important factor affecting innovation performance. The higher the level of R&D investment, the better the effect of improving innovation performance.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

Enterprise R&D is a complex and high-tech activity. It requires not only machinery and equipment as a hardware guarantee, but also software support of enterprise human capital, such as the knowledge, experience and professional skills of the labor force. Therefore, the innovation of human capital to the enterprise is also generated. With a greater impact, this article further proposes Hypothesis 2:

Hypothesis H2: Human capital is another important factor affecting enterprise innovation. The higher the level of human capital invested by the enterprise, the better the innovation performance of the enterprise.

According to the capital-skill complementarity hypothesis, companies can only improve the utilization of resources and optimize the efficiency of corporate innovation only when people and things cooperate. Therefore, this article further proposes Hypothesis 3:

Hypothesis H3: The company's R&D investment and human capital have complementary effects on the company's innovation performance. In the company's R&D activities, the complementarity of the two will have an additional boost to the company's innovation.

4. RESEARCH DESIGN

4.1. Data Source

In order to verify the above hypothesis and take into account the availability of human capital data, this article uses China's A-share non-financial listed companies from 2010 to 2019 as a research sample. To enhance the representativeness of the data, we filter and process the data as follows:

(1) Exclude companies with abnormal operations during the sample period, such as ST and ST* companies; (2) Exclude companies with abnormal financial data, patent data, and employment structure data. After the above processing, this paper finally obtained 2411 valid enterprise samples and 24,070 "enterprise-annual" level observations. In the subsequent empirical process, due to the slightly different degree of missing variables used in each regression, the sample size will also be different. Changes follow. The main sources of data in this article are iFinD database, Wind database and Choice database.

4.2. Variable Description

This article studies the complementary effects of enterprise R&D investment and human capital on enterprise innovation performance. Therefore, the explanatory variable is the enterprise’s innovation performance, and the explanatory variable is the enterprise’s R&D investment and human capital.

Explained variable. Enterprise innovation performance has many aspects, such as direct performance such as patents generated by technological innovation investment and new product sales revenue, but also indirect performance such as improved human capital level, strengthened management level, and equipment technology update. However, in view of the availability of data and the representativeness of the variables, this article selects the number of patents (patent) as the proxy variable of innovation performance. The value of this variable is summarized by the number of innovations of invention patents, utility models and designs disclosed in the company’s annual report. Obtained, specifically using the natural logarithm of the total number of the three types of innovation plus 1 to measure.

Explanatory variables. The measurement indicators of R&D investment used by most scholars mainly include “R&D expenditure/total income”, “R&D expenditure/total assets” and “R&D expenditure/corporate value”. The natural logarithm of 1 is used as a measure of the company's R&D investment, and the relative amount (Investment_ratio) uses the natural logarithm of the company's R&D expenditure in operating income as a measure of the

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

company's R&D investment. Human capital is the sum of physical strength, knowledge, experience and other skills carried by laborers. From the perspective of education level, this article first classifies laborers with a college degree or above as high-educated laborers and technical secondary school. Workers with education qualifications and below are classified as low-educated workers, and the natural logarithm (high_ratio) of the proportion of high-educated workers is used to indicate the level of human capital of the enterprise. In the robustness test, this article distinguishes human capital according to the nature of the work of the workers, regards technical personnel as skilled labor, and other personnel as unskilled labor, and uses the natural logarithm of the proportion of technical personnel (skill_ratio) to indicate the level of human capital in the enterprise.

Table 1. Descriptive statistics of main variable

variables	sign	sample	Mean	Standard deviation	Minimum	Max
The logarithm of the number of company patents	Patent	19,975	1.654	1.654	0.693	10.886
Logarithm of the proportion of highly educated labor	high_ratio	24,070	3.224	1.375	0.000	4.615
Logarithm of skilled labor	skill_ratio	24,070	2.539	1.092	0.000	4.615
Logarithm of R&D investment amount	Investment	19,326	3.893	1.480	0.000	9.993
Logarithm of R&D investment as a percentage of revenue	Investment_ratio	19,326	0.958	1.176	-2.303	5.133
Logarithm of total assets	asset	23,850	3.688	1.361	0.000	10.216
Logarithm of cash and cash equivalents	cash_equivalent	23,819	1.887	1.139	-1.014	8.044
Company age	age	24,070	18.468	6.183	1.000	65.000
Logarithm of operating income	revenue	23,837	3.102	1.420	0.000	10.298
Assets and liabilities	Debt /Asset	23,846	43.430	26.952	0.708	984.109

Control variables. Enterprise size (asset) is expressed by the natural logarithm of total assets plus 1; the logarithm of cash and cash equivalents (cash_equivalent) is expressed by the natural logarithm of the amount of cash and cash equivalents at the end of the period plus 1; enterprise age (age) is expressed by the current year The difference with the year of establishment of the company is expressed; profitability (revenue) is expressed by the natural logarithm of total operating income plus 1; the debt-to-asset ratio (Debt /Asset) is expressed by the ratio of total liabilities to total assets.

4.3. Empirical Model

When discussing the complementary effects of R&D investment and human capital on innovation performance, we must first examine the effects of the two alone on corporate innovation performance. This article uses a two-way fixed effect and sets the regression model as follows:

$$\text{Patent}_{\text{it}} = \alpha_0 + \beta_1 \text{Investment}_{\text{it}} + \beta_2 \text{X}_{\text{it}} + \delta_{\text{i}} + \delta_t + \varepsilon_{it} \quad (1)$$

$$\text{Patent}_{\text{it}} = \alpha_0 + \beta_1 \text{high\_ratio}_{\text{it}} + \beta_2 \text{X}_{\text{it}} + \delta_{\text{i}} + \delta_t + \varepsilon_{it} \quad (2)$$

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

$$\begin{aligned}\text{Patent}_{\text{it}} &= \alpha_0 + \beta_1 \text{Investment}_{\text{it}} \times \text{high\_ratio}_{\text{it}} + \beta_2 \text{Investment}_{\text{it}} \\ &+ \beta_3 \text{high\_ratio}_{\text{it}} + \beta_4 \text{X}_{\text{it}} + \delta_{\text{i}} + \delta_t + \varepsilon_{it}\end{aligned} \tag{3}$$

Among them, i and t represent the company, industry, province, and year respectively. Patent is an explained variable, which represents the logarithm of the number of patents owned by a company. Investment and high_ratio are core explanatory variables, which respectively represent the "logarithm of the amount of R&D investment" and "logarithm of the proportion of highly educated labor force". Model (3) is to estimate the complementary effects of the key research in this article, and the interaction coefficient α1 reflects the complementary effects of R&D investment and human capital on enterprise innovation performance. X represents the control variables at the enterprise level, which mainly include total assets, cash flow, age, profitability, return on net assets, etc. δi and δt represent firm fixed effects and time fixed effects, respectively, and εit is a random disturbance term.

5. EMPIRICAL RESULTS

5.1. Benchmark Regression Results

R&D capital investment and human capital are indispensable elements of R&D. This section examines whether these two elements will promote the innovation performance of enterprises. R&D is an exploratory activity with a long time span. It takes a long time from input to output. Sometimes there is no input but no output. Therefore, when examining the impact of each element on R&D output, this article will Regression is performed after a period of lag, and the specific regression results are shown in Table 2.

Table 2. Benchmark regression test results

	Patent			
	(1)	(2)	(3)	(4)
Investment_1	0.197***		0.119***	
	(0.007)		(0.007)	
high_ratio_1		0.049***		0.028***
		(0.004)		(0.004)
cash_equivalent			-0.030***	-0.035***
			(0.009)	(0.009)
Debt /Asset			0.000	0.001**
			(0.000)	(0.000)
age			0.157***	0.163***
			(0.002)	(0.002)
asset			0.383***	0.400***
			(0.017)	(0.016)
revenue			-0.058***	-0.014
			(0.014)	(0.014)
Constant	2.876***	3.171***	-0.127***	-0.347***
	(0.024)	(0.015)	(0.040)	(0.039)
Observations	16,164	18,343	16,154	18,329
R-squared	0.930	0.925	0.934	0.931
δi, δt	YES	YES	YES	YES

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

Note: *, **, and *** indicate significant at the levels of 10%, 5%, and 1%, and standard deviations in parentheses; δi and δt represent firm and year fixed effects, and the following tables are the same.

Columns (1) and (2) respectively report the impact of enterprise R&D investment and human capital on innovation performance when the individual and time fixed effects of the enterprise are controlled, respectively, measured by the enterprise's capital investment and the proportion of highly educated labor force. It was found that the regression coefficients of the two were 0.197 and 0.049, respectively, and both were significantly positive at the 1% level. Columns (3) and (4) have joined the control variables at the enterprise level, and it can be found that the regression coefficients of the two are still significantly positive. Therefore, the results of the benchmark regression show that the investment in R&D capital and the employment of highly educated labor promote the R&D of the enterprise, thereby improving the innovation performance of the enterprise. Therefore, this result provides preliminary support for Hypothesis 1 and Hypothesis 2 of this article. Enterprise R&D investment and human capital are important factors that affect innovation performance, and the investment level of the two is positively correlated with the innovation performance of the enterprise.

5.2. Robustness Test Results

In order to ensure the reliability of the above-mentioned research results, this article will replace the proxy variables of the explanatory variables for robustness testing. The specific regression results are shown in Table 3.

Table 3. Benchmark regression test results

	Patent	
	(1)	(2)
Investment_ratio_1	0.120*** (0.008)	
skill_ratio_1		0.056*** (0.005)
Controls	YES	YES
Observations	16,154	18,329
R-squared	0.933	0.931
δi, δt	YES	YES

Note: Controls means control variables. The control method is consistent with the columns in Table 2. The control variables and constant items cannot be reported due to space limitations, the same below.

Column (1) uses the proportion of R&D capital investment in operating income to measure the level of R&D investment of a company, and further examines the impact of R&D investment on corporate performance innovation. It can be found that the coefficient of the explained variable is 0.12, which is still at the level of 1%. Significantly. Column (2) uses the proportion of the company's technical labor force to measure the company's human capital level. It can be found that the coefficient of the explained variable in the test result is 0.056, which is still very significant. The two results indicate that the R&D investment and human capital of enterprises have a relatively stable role in promoting enterprise innovation performance.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

5.3. Regression Results of Complementary Effects

The previous article has tested that enterprise R&D capital and human capital are indispensable elements of R&D activities, and the investment of both promotes the innovation performance of the enterprise. However, the knowledge of the above results shows that the two factors have unilateral effects on R&D output. Whether capital and manpower show complementary effects in R&D activities is the key issue of this paper. For this reason, we tested this based on the benchmark regression model. Complementarity does exist, and the specific regression results are shown in Table 4.

In the regression results, we need to focus on the coefficient of the interaction term between R&D investment and human capital. Column (1) only controls the individual and time fixed effects, and reports the complementary effect of the total R&D investment and the proportion of highly educated labor on innovation performance. It can be found that the coefficient of the interaction term is 0.007, which is significant at the 5% level. Column (2) adds enterprise-level control variables, and the coefficient of the interaction term is significantly positive at the 1% level, indicating that capital and manpower not only promote the R&D output of the enterprise individually, but more importantly, they can complement each other. The role of the company to further promote the research and development of enterprises.

Table 4. Complementary effect test results

	Patent				
	(1)	(2)	(3)	(4)	(5)
Investment_1* high_ratio_1	0.007** (0.003)	0.010*** (0.003)			
Investment_ratio_1* high_ratio_1			0.007* (0.004)		
Investment_1* skill_ratio_1				0.012*** (0.004)	
Investment_ratio_1* skill_ratio_1					0.013*** (0.005)
Investment_1	0.171*** (0.012)	0.085*** (0.012)		0.163*** (0.012)	
Investment_ratio_1			0.098*** (0.014)		0.055*** (0.015)
high_ratio_1	0.007 (0.011)	-0.021** (0.010)	0.004 (0.006)		
skill_ratio_1				0.022* (0.013)	0.050*** (0.008)
Controls	NO	YES	YES	YES	YES
Observations	16,164	16,154	16,154	16,164	16,164
R-squared	0.930	0.934	0.934	0.930	0.927
δi., δt	YES	YES	YES	YES	YES

In order to ensure the robustness of the results, this paper selects the proportion of R&D investment in operating income and the proportion of technical labor to test the complementary effects respectively, and adds fixed effects and control variables. The specific report results are shown in columns (3), (4) and (5) The test results are still in line with expectations, and the interaction coefficients are all significantly positive. This result verifies the hypothesis 3 of this article. The company's R&D investment and human capital have a complementary effect on the company's innovation performance. In the company's R&D

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

activities, The complementarity of the two will have an additional boost to the innovation of enterprises.

5.4. Results of Heterogeneity Test

After testing the complementarity of capital and human input to the R&D output of enterprises, this article starts from the heterogeneity of different enterprises and explores whether there are detailed differences in this complementarity of different enterprises.

First consider whether the company's main business is a strategic emerging industry developed by the country. The company is divided into two parts: emerging industries and non-emerging industries. Table 5 columns (1) and (2) respectively report the interaction between R&D investment and human capital The impact on innovation is heterogeneous at the level of emerging industries. It can be found that the interaction of R&D investment and human capital on the innovation results of enterprises whose main business is emerging industries is not very significant, and the coefficient of the interaction term is 0.009, For companies whose main business is a non-emerging industry, the interaction is very significant, and the regression coefficient has also increased compared to the full sample. This shows that companies that belong to non-emerging industries are more fully reflected in the role of "people" in R&D activities and pay more attention to the investment of "people and things". This is also easier to understand, because the characteristics of emerging industries are that they pay more attention to the investment of capital and machinery and equipment in the early stage, and the entire R&D innovation cycle is longer. The integration of "people and things" in the R&D process is not as high as the general manufacturing industry.

Table 5. Test results of heterogeneity of production factors

	Patent		
	capital-intensive	technology-intensive	labor-intensive
Investment_1*	0.008	0.014***	0.008
high_ratio_1	(0.020)	(0.004)	(0.006)
high_ratio_1	-0.081	-0.080***	-0.006
	(0.064)	(0.015)	(0.022)
Investment_1	0.120	0.074***	0.094***
	(0.073)	(0.016)	(0.022)
Controls	YES	YES	YES
Observations	925	10,471	4,059
R-squared	0.903	0.940	0.940
δi, δt	YES	YES	YES

In order to test the robustness of our conclusion, this article takes the "Administrative Measures for the Accreditation of High-tech Enterprises" jointly issued by the Ministry of Science and Technology, the Ministry of Finance, and the State Administration of Taxation (Guoke Fahuo [2016] No. 32) as an example. Whether the business belongs to the high-tech industry in the recognized management measures, the enterprise is divided into two parts: high-tech industry and low-tech industry. Columns (3) and (4) of Table 5 respectively report the impact of the interaction between R&D investment and human capital on the innovation of high- and low-tech industries. It can be found that similar to the previous emerging industries, the interaction is not significant , And it is very significant in low-tech industries, and the coefficient is also greatly improved compared to the full sample. The high-tech industries are similar to the emerging industries mentioned above, which further shows that our results are relatively stable.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

In addition, from the perspective of production factors, this article divides the industries into capital-intensive, technology-intensive and labor-intensive, and examines the impact of the interaction between R&D investment and human capital on the innovation of the three different types of enterprises. Table 6 Columns (1), (2), and (3) respectively report the complementary effects of capital-intensive, technology-intensive, and labor-intensive enterprises. It can be found that the innovation impact of capital-intensive and labor-intensive enterprises is not significant and has no significant impact on technology-intensive enterprises. The impact of type innovation is very significant, this is in line with expectations. Because capital-intensive and labor-intensive companies may not pay much attention to product and technology innovation, and technology-intensive companies pay more attention to innovation, which may be the basis for their development in competition, so the interaction is in technology-intensive companies It's very obvious.

6. CONCLUSION AND ENLIGHTENMENT

6.1. Main Research Conclusions

This paper constructs a two-way fixed-effect model, using the detailed classification data of R&D investment, employment structure and patent data of listed companies from 2010 to 2019 to test the relationship between R&D investment, human capital and corporate innovation performance. The results show that the increase in R&D investment has significantly improved the innovation performance of enterprises, no matter in absolute or relative amount. The level of human capital of an enterprise is measured by the level of academic qualifications and technology, and it is found that the improvement of human capital has significantly improved the innovation performance of the enterprise. In addition, this article further finds that R&D investment and human capital have complementary effects on corporate performance innovation, and the combination of the two elements has an additional role in promoting corporate innovation. Finally, this paper also studies the heterogeneity of complementary effects, and finds that the complementary effects of R&D investment and human capital have certain heterogeneity in the types of industrial technology and the types of enterprise factor endowments.

6.2. Policy Implications

The research conclusions of this paper have the following two policy enlightenments: First, the R&D investment and human capital of Chinese enterprises have a significant promotion effect on enterprise innovation, and the two are hardware and software guarantees for improving quality and efficiency of enterprises. At the critical stage of the current economic transformation and upgrading, this article believes that it will promote the coordinated upgrading of enterprise material and human capital, thereby increasing the productivity of the two factors, and ultimately forming a high-efficiency and high-quality supply. Second, human capital may often be ignored by entrepreneurs, and it is precisely an important resource for an enterprise to innovate and upgrade, and for a country to achieve high-quality economic development. This article believes that investment in people should be increased in basic education and technical training, on the one hand, to improve the ability of skilled labor to learn and use new technologies, on the other hand, to improve the skill level and productivity of unskilled labor, and transform the demographic dividend into human capital. Dividends to ensure the smooth and orderly progress of economic transformation and upgrading.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202202_8(2).0029

REFERENCES

[1] Sun Hui, Wang Hui. Government Subsidies, R&D Investment and Enterprise Innovation Performance: An Empirical Study Based on High-tech Enterprises on the Growth Enterprise Market, Science and Technology Management Research,vol. 12 (2017),111-116.

[2] Xie Xuemei, Dai Zhihua, Liu Siyu. High-tech R&D investment and new product innovation performance of high-tech enterprises: a comparative study based on panel data, Industrial Engineering and Management, vol.18 (2013) No. 3,p.92-96.

[3] Qiu Yunjie, Wei Wei. The impact of R&D investment on corporate performance——A study based on propensity score matching method, Contemporary Finance, vol.3(2016), 96-106.

[4] Arrow K J. The Economic Implications of Learning by Doing, The Review of Economic Studies, vol.29(1962) No. 3,p.155-173.

[5] Li Wei'an, Li Haobo, Li Huicong. Innovation incentives or tax shields?—Research on tax incentives for high-tech enterprises, Scientific Research Management, vol.37(2016)No.11,p. 61-70.

[6] Heckman, J. J. 2005, ”China's Human Capital Investment”, China Economic Review,vol.16(2005)No. 1,p.50—70.

[7] Salazar-Acosta M. Innovation systems based indicators: Emphasis on human capital and ICT adoption, Centre for Policy Research on Science and Technology,(2006), 06-03.

[8] Hall B H, Lotti F, Mairesse J. Evidence on the impact of R&D and ICT investments on innovation and productivity in Italian firms, Economics of Innovation and New Technology, vol.22(2013)No.3 ,p.300-328.

[9] Gong Yifei, Xia Yanchun. Internal control quality, R&D investment and corporate performance, Friends of Accounting, vol.18(2017), 35-39.

[10] Luo Jia, Liu Yeyun. The impact of R&D investment on innovation performance of listed manufacturing companies: based on the moderating effect of equity structure, Collection,vol.7(2018) .

[11] Feng Wenna. Research on the Relationship between R&D Input and Innovation Output of High-tech Enterprises——Based on the Empirical Study of High-tech Enterprises in Shandong Province, Economic Issues, vol.9(2010), 74-78.

[12] Kang Zhiyong. Technology choice, investment intensity and enterprise innovation performance research, Science Research Management, vol.34 (2013) No.6 ,p.42-49.

[13] Kim M. Cross-industry distribution of R&D investments and economic growth, [Applied Economics Letters, vol.27 (2020) No8, p.679-684.

[14] Scherer F M. Firm size, market structure, opportunity, and the output of patented inventions, The American economic review, vol.55(1965) No.5,p.1097-1125.

[15] Chen C J, Huang J W. Strategic human resource practices and innovation performance—The mediating role of knowledge management capacity, Journal of business research, vol.62(2009) No1p.104-114.