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The Impact of R&D Input of High Tech Industries in the Silk Road Economic Belt on the Innovation Output of Enterprises

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Abstract: *The Silk Road Economic Belt is an important strategy of China at present and a reflection of China's adherence to opening up. While China's economy is in the stage of transformation from high-speed development to high-quality development, the implementation of innovation driven strategy is an effective means to speed up the transformation. Using panel data of high-tech industries in 9 provincial administrative divisions along the Silk Road Economic Belt from 2009 to 2016 to empirically analyze the relationship between government R&D funding, enterprise R&D expenditure and enterprise innovation output. According to BP-LM test and Hausman test, the fixed effect model was finally selected for regression analysis. The results show that the government's direct investment in R&D of high-tech enterprises and the enterprise's own investment in R&D can promote the innovation output of enterprises. The impact coefficient of the enterprise's investment in human factors on the innovation output of enterprises is negative, but not significant. Based on the above research results, this paper puts forward suggestions for the government to introduce relevant R&D support policies to improve the effect of government R&D subsidies.*

Keywords: *Silk Road Economic Belt; R&D input; High technology industry; Innovation output*

1. Introduction

China is vigorously promoting the construction of the Silk Road Economic Belt, and the innovation output is the key issue for the high-quality construction of the Silk Road Economic Belt. China's economic development is in the stage of transformation from high-speed growth to high-quality development. Improving the quality of economic development by implementing the innovation driven development strategy is an effective way to transform the mode of economic growth. Increasing the innovative output of enterprises in the Silk Road Economic Belt will play a powerful role in promoting the high-quality construction of the Silk Road Economic Belt. At the same time, it is also one of the major measures taken by the areas along the Silk Road Economic Belt to deepen the reform of the scientific and technological system and mechanism and promote the close integration of scientific and technological innovation and economic output.

R&D (Research and Development) refers to systematic and creative activities in the field of science and technology to increase the total amount of knowledge and use these knowledge to create new applications, including basic research, applied research and experimental development. R&D investment is an important prerequisite for enterprises' microeconomic innovation and a direct source of funds for enterprises' technological innovation. Enterprises need to improve their technological innovation capability through continuous R&D investment. The original intention of the government to support enterprise innovation is to play an additional role and guide enterprises to increase R&D investment with limited support. Under the guidance of the strategy of rejuvenating the country through science and technology, the government will invest a large amount of funds every year to support the technological innovation of enterprises. *Ehie et al.* (2010) believed that the increase of independent R&D investment of enterprises can significantly improve the innovation performance of enterprises[1]; *Fan Qi* and *Han Minchun* (2011) believed that China's government innovation R&D subsidy investment policy has a very significant impact on the improvement of national and regional independent innovation output. Through the comparative analysis of the elasticity coefficient of patent output and value-added innovation output indicators of high-tech industries, it was found that China's R&D investment in patent output is diminishing returns to scale, and the value-added of high-tech

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industries is increasing returns to scale[2]; *Liu Xiaoyuan* and *Lin Song* (2013) believe that local government subsidies have a positive correlation with R&D capital investment and R&D human resources investment of start-ups, which supports the incentive effect hypothesis of local government subsidies[3]; *Ye Mingque* and *Wang Kunqing* (2019) believe that government R&D investment is the key policy means for the government to encourage enterprises to innovate independently, and the incentive effect of government R&D investment on the innovation performance of high-tech enterprises is far greater than its crowding-out effect on enterprises' own scientific research investment[4]; *Zhou Fen* and *Li Xifan* (2020) believed that the effect of government R&D funding on enterprise innovation output was significantly different in different regions of China; Government R&D investment has a certain crowding effect on enterprise R&D output[5]; *Jin Chengguo, Dayao Li and Xu Zhang* (2020) believed that the number of R&D institutions, R&D projects and new product development expenditures have a significant positive impact on the level of technological innovation in high-tech industries[6]. *Deng Feng* [7](2021) and *Chen Jie* [8](2021) believes that government support has a significant positive impact on the technological innovation performance of enterprises, and government support has a significant positive impact on enterprise R&D investment.

2. Model setting and data description

2.1. Model setting

Griliches (1979) used Cobb Douglas production function to derive the marginal rate of return of each input factor on productivity[9]. According to Griliches' research, this paper adopts the expanded Cobb Douglas production function and sets the following model:

$$Y = C \cdot K_G^{\beta 1} \cdot K_F^{\beta 2} \cdot RDE^{\beta 3} \quad (1)$$

Y represents the innovation output of enterprises. Generally, the most direct indicator for measuring the level of innovation output of enterprises is patent output. Therefore, this paper uses the number of effective invention patents as the measurement indicator of enterprise innovation output.K_G represents the direct investment of government finance to enterprise R&D.K_F is the enterprise's own R&D investment.RDE represents the enterprise's investment in human resources. In this paper, R&D personnel equivalent full-time equivalent is selected as the measurement indicator. C is a constant.

Considering that business ability will also have a certain impact on the use of scientific research funds and the level of innovation output of enterprises, this paper takes business ability as a control variable to investigate the effect of government R&D funding, measured by enterprise profit rate, expressed in Pro. Take logarithms on both sides of equation (1) and add control variables to obtain the following model, μ Is an error item. Considering that R&D activities usually need to go through a long period from obtaining capital, labor and other inputs to obtaining results and outputs, in this paper, the government's direct capital investment in enterprise R&D, the enterprise's own R&D capital investment, and the enterprise's R&D human input are all delayed by one period. The following model is obtained:

$$\ln Y_{it} = \alpha_i + \beta_1 \ln K_{Gi,t-1} + \beta_2 \ln K_{Fi,t-1} + \beta_3 \ln RDE_{i,t-1} + \beta 4 Pro_{it} + \mu_{it} \quad (2)$$

2.2. Data description

The research object of this paper is high-tech industries in 9 provinces and regions along the Silk Road Economic Belt (Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Chongqing, Sichuan, Yunnan, Guangxi). The data used in this paper are from the 2009-2016 China Science and Technology Statistical Yearbook and China High-tech Industry Statistical Yearbook.

3. Empirical results and analysis

3.1. Model selection

Through BP-LM test and Hausman test, we can choose whether to use mixed OLS model, fixed effect model or random effect model for regression. The test results are shown in Table 1. The p-value of the BP-LM test result is 0.0035, which strongly rejects the original hypothesis that "there is no individual random effect", that is, the random effect model should be selected between the random effect model and mixed regression. However, the p value of Hausman test result is 0.0000, indicating that fixed effect model should be selected in random effect model and fixed effect model.

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Table 1: Result of model selection

BP-LM test statistics and P-value	Hausman test statistics and P-value	Model selection
chibar2(01)=7.28 p=0.0035	chi2(4)=79.995 p=0.0000	Fixed effect model

3.2. Result analysis

According to the model selection results in Table 1, the fixed effect model is selected for regression of (2). The results show that in the nine provinces and regions along the Silk Road Economic Belt, the influence coefficient of the government's direct capital investment in R&D of enterprises on the innovation output of high-tech enterprises is positive, and is significant at the level of 5%, indicating that the government's direct capital investment in R&D of high-tech enterprises has a promoting effect on the innovation output of enterprises. It shows that the government's direct capital investment can effectively alleviate the negative impact of R&D capital shortage on innovation output of high-tech enterprises.

The results are shown in Table 2. The influence coefficient of the enterprise's own R&D capital investment on the enterprise's innovation output is positive, which is significant at the level of 10%, indicating that the enterprise's own R&D capital investment has a promoting effect on the enterprise's innovation output, and the influence coefficient is greater than that of the government's direct investment on the enterprise's innovation output, indicating that the enterprise's own R&D capital investment has a greater impact on the enterprise's innovation output, This may be because the government's R&D investment is selective, so when the enterprise receives the funding, it also transmits the information that the technology R&D project is confirmed to the outside world. This information will attract the participation of external private investment, and the enterprise will obtain more sufficient R&D funds.

The impact coefficient of enterprises' input in human factors on enterprises' innovation output is negative, but not significant. It shows that human capital investment in scientific research has not yet played an effective role in promoting the innovation output of enterprises. This is the same as the research results of Zhou Fen (2020) and others. This may be due to the irrationality of the internal staff management system of the enterprise, which inhibits the enthusiasm of R&D personnel to carry out R&D activities, makes the enterprise fail to realize the effective allocation of human capital in scientific and technological development, and reduces the efficiency of the enterprise's innovation output. This also reminds enterprises that they need to further improve their internal staff management mechanism, improve the efficiency of the transformation of R&D human input into enterprise innovation output, and improve the enthusiasm of scientific and technological developers in research and development.

The influence coefficient of enterprise management capability on enterprise innovation output is positive and significant at the level of 5%. The results show that the stronger the enterprise's own management ability, the stronger the enterprise's innovation output ability. This also shows that enterprises with strong operating ability are also stronger than enterprises with weak operating ability in the efficiency of transformation of innovation achievements. Enterprises with higher profits are also more willing to invest in enterprise R&D.

Table 2: The impact of R&D input on enterprise innovation output

	$\ln Y_{it}$
$\ln K_{Gi,t-1}$	0.4156** (0.14)
$\ln K_{Fi,t-1}$	0.7381* (0.33)
$\ln RDE_{i,t-1}$	-0.3021 (0.45)
Pro_{it}	0.0021** (0.00008)

Note: * , * * indicate the significance level of 10% and 5% respectively

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3.3. Robustness check

The robustness is tested by replacing the explained variables. The explained variable is the innovation output of the enterprise. In the original regression results, the number of effective invention patents is used as a measure of the innovation output of the enterprise. Here, the number of effective invention patents is replaced by the number of patent applications. The inspection results are shown in Table 3.

Table 3: Results of robustness test

	$lnPA_{it}$
$lnK_{Gi,t-1}$	0.4656*** (0.11)
$lnK_{Fi,t-1}$	0.4335** (0.18)
$lnRDE_{i,t-1}$	-0.6994*** (0.21)
Pro_{it}	0.0018 (0.0021)

Note: *, * * and * ** indicate the significance level of 10%, 5% and 1% respectively

The results show that the coefficient between the direct investment of government finance in R&D of enterprises and the innovation output of enterprises is positive; The coefficient between the enterprise's own R&D investment and the enterprise's innovation output is positive; The coefficient between enterprises' input in human factors and innovation output is negative; The coefficient between the enterprise's operating capacity and the enterprise's innovation output is positive. The above results are basically consistent with the results obtained in the previous article, indicating that the impact of government capital investment, enterprise's own capital investment, enterprise's investment in human resources and enterprise's operating capacity on enterprise innovation output is robust.

4. Policy recommendations

From the perspective of provincial and regional panel data, this paper analyzes the impact of R&D investment on the technological innovation output of high-tech enterprises in 9 provinces and regions along the Silk Road Economic Belt. The results show that the direct investment of government finance in R&D of enterprises and the R&D investment of enterprises have a significant positive impact on the innovation output of high-tech enterprises. Based on the above research results, this paper puts forward suggestions on the relevant R&D support policies issued by the governments of 9 provinces and regions along the Silk Road Economic Belt for high-tech industries to improve the effect of government R&D subsidies.

The government's direct investment in R&D of enterprises is an effective means to promote enterprises to carry out innovative R&D activities and obtain innovative output. In addition to making up for the shortage of R&D funds, it can also attract external investment, which is of great significance for the supplement of research funds and has an obvious incentive effect on the innovative output of high-tech enterprises. Therefore, the local government should further and continuously increase the scientific and technological support for high-tech enterprises. At the same time, the government also needs to comprehensively consider such factors as the operating conditions of enterprises and the development prospects of similar enterprises, and the funding of different types of enterprises should be focused on and reasonably allocated. For example, enterprises with good development prospects should be given proper attention, and enterprises with good operating conditions should be given reasonable incentives, so as to maximize the incentive effect of government R&D investment.

In addition to the impact of capital, innovation efficiency is also of great significance for improving the innovation output of enterprises. The efficiency of innovation is not high. It only blindly increases R&D investment, but also cannot effectively increase innovation output, and will also lead to waste of input resources. After the improvement of innovation efficiency, more innovation results can be produced under the limited resource input, which is a benign innovation development path. Therefore, in order to encourage enterprises to improve the efficiency of innovation transformation, the relevant government subsidies can be linked to the innovation efficiency of high-tech industries to a certain extent. Enterprises with high efficiency of innovation transformation can be encouraged to form a virtuous circle and promote the output of innovation achievements.

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5. Conclusion

The research results show that enterprises' own R&D capital investment also has a significant positive impact on their innovation output, so enterprises should continue to increase their own R&D capital investment and drive development through innovation. The R&D activity is a long-term and continuous activity, which requires a long time of continuous investment, and it also needs a certain time to invest into the output of results, which means that there is a certain lag effect in capital investment. Therefore, when formulating relevant policies, the continuity of R&D investment should be maintained in the stage where the achievements have not been achieved in the short term to prevent the early investment from being wasted due to the termination of capital injection. At the same time, it is also required that the feasibility study of the R&D project before the project is approved should be strictly controlled by the enterprise to reduce the possibility of capital depletion from the source.

The research results also show that the impact coefficient of the enterprise's investment in human resources on the enterprise's innovation output is negative, which also indicates that enterprises need to constantly improve the enterprise management mechanism and system in the process of operation and management, pay attention to improving the overall quality and management efficiency of R&D personnel, implement a fair and reasonable performance appraisal and reward system, improve the enterprise's own management efficiency, and improve the efficiency of capital utilization, To enable researchers to transform their creativity into the innovative output capacity of enterprises. Provinces and regions along the Silk Road Economic Belt should encourage scientific researchers to actively participate in the competition, undertake various vertical and horizontal scientific research projects, and improve the subjective initiative of scientific researchers. It is necessary to optimize the quality structure of scientific research team members, formulate relevant preferential policies, actively introduce high-level talents engaged in high-tech development in line with the characteristics of regional economic development and engineers based on the front line of enterprise production, and form an excellent scientific and technological innovation team. At the same time, we should strengthen cooperation with enterprises and actively apply scientific research and innovation achievements to the production practice of enterprises, which can not only obtain relevant funds to invest in research and development again, but also enable enterprises to gain profits, and continuously improve the transformation rate of scientific and technological innovation of high-tech enterprises in provinces and regions along the Silk Road Economic Belt on this interdependent chain.

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