# Research on the Impact of Government R&D Funding on Innovation Performance of High-Tech Enterprises

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**Abstract.** This paper takes 611 listed high-tech enterprises in China from 2015 to 2019 as research samples, uses empirical methods to test the relationship between government R&D funding and high-tech enterprises' innovation performance, and discusses the mediating role of enterprises' innovation behavior between the two studies have shown that: the two *R&D* funding methods of the government for listed high-tech companies in China can improve the enthusiasm of companies to conduct innovative behaviors and increase research investment; government R&D funding may have a significantly positive impact on firm innovation performance, while direct government funding can lead to better results; firm innovation behavior plays a mediating role between government R&D funds and firm innovation performance.

**Keywords:** Government R&D funding · R&D investment · Innovation performance · High-tech enterprise

## 1 Introduction

With the rapid development of science and technology around the world, innovation is playing an increasingly important role and gradually becoming the primary driving force for development. Enhancing the capacity for entrepreneurship and innovation is an important way to improve a country's scientific and technological level and core competitiveness. High-tech enterprises are an important part of listed companies, with unique innovation and rapid growth characteristics.

As the forerunner of scientific and technological innovation, high-tech enterprises play an important role in promoting the innovation and development of traditional industries, modernization and strategic industries, and in promoting scientific and technological innovation and high-quality development of economy and society, which have been highly praised by the Party and the state for further development. The government has long recognized that R&D opportunities for enterprises are a source of competitiveness for enterprises and a driving force for public competitiveness. So the government has also tapped public resources by increasing investment in companies' own research and development. Government R&D subsidy has become an important factor for enterprises


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to carry out innovation activities and promote innovation. In order to give full play to the innovation and development advantages of high-tech enterprises, strengthen the supporting and leading role in the key tasks of high-quality development of strategic industries, Governments have begun to intervene to support the growth of high-tech companies through the use of R&D funding, project support, tax incentives and other policy tools and measures.

## 2 Theoretical Analysis and Research Hypothesis

### 2.1 Government R&D Funding and Firm Innovation Behavior

The technological innovation activities of enterprises are mainly based on two types of regulation: One is market mechanism; the other is government macro-control. In the formation process of national innovation capability, the guiding role of government cannot be ignored.

J discussed two ways of R&D competition and cooperation, both of which confirmed that government R&D subsidy would stimulate enterprises to increase R&D investment [1]. Chen divides innovation into R&D investment activities, risk-related R&D activities and external technology acquisition based on the perspective of enterprise micro-R&D and innovation process [2]. Li et al. believe that there is a significant positive correlation between tax incentives and R&D intensity of enterprises, which is conducive to stimulating enterprises to carry out independent innovation [3]. Yang et al. used evolutionary game model to explore the incentive effect of government subsidies on enterprises' technological innovation behavior [4]. Fu et al. found that government direct subsidies and tax rebates have an incentive effect on enterprises' innovation behaviors [5]. Cui et al. conducted a case study and believed that the additional deduction policy for R&D expenses promoted the development of enterprises' innovation behavior [6].

H1: Direct government R&D funding has a positive impact on enterprises' innovation behavior.
H2: Government indirect R&D funding has a positive impact on enterprises' innovation behavior.

### 2.2 The Impact of Government R&D Funding on Enterprise Innovation Performance

There are two ways for the government to subsidize the R&D of high-tech enterprises: Direct and indirect funding. Enterprises receive direct funding from the government, which is used for government subsidies for R&D projects and direct R&D subsidies. Preferential income tax rates, additional deductions for R&D expenses, and other common forms of indirect government R&D funding are related to financial contributions and support of income and price for specific goals, groups or organizations through national and municipal financial policies. Both of these two funding methods have advantages and disadvantages in the process of stimulating enterprise innovation, and are complementary to some extent.

Direct subsidy is an incentive policy in advance the more direct subsidies enterprises receive from the government, the more R&D investment they can make. The research of Zhou et al. shows that, compared with indirect funding, direct funding can better promote the improvement of enterprise innovation performance [7]. Li et al. studied three types of fiscal policies: Government subsidies, tax cuts and exemptions for high-tech enterprises, and research tax breaks that can increase the innovation rate of high-tech enterprises [8]. Chen points out in his research that government subsidies improve the innovation performance of high-tech enterprises in the manufacturing industry [9]. Ning et al. empirical results show that at different stages of enterprise development, fiscal subsidies and tax incentives have significantly different innovation incentive effects on enterprises [10]. Qin et al. believe that tax incentives cannot significantly improve the efficiency of issuing innovation [11]. Sun et al. used the dynamic threshold model to analyze and conclude that tax reduction policies have a significant promoting effect on enterprise innovation used the propensity score matching method to analyze the impact of government R&D funding on the innovation performance of different types of enterprises, and concluded that government R&D funding can have a significant incentive effect on the innovation performance of micro enterprises [12].

H3: Direct government R&D funding has a positive impact on enterprise innovation performance.
H4: Government indirect R&D funding has a positive impact on enterprise innovation performance.

### 2.3 The Influence of Firm Innovation Behavior on Innovation Performance

Enterprises have different innovative behaviors at different development stages: Entrepreneurial period, enterprises focus on product and process innovation; When an enterprise is in the growth stage, the focus of innovation turns to expanding production scale, expanding market and establishing corporate image. The most brilliant period of the enterprise is the mature period, at this time the market competition is the most intense, enterprises face more problems. Different from the early stage, enterprises will carry out a variety of different innovative behaviors. In order to obtain a second life, enterprises in the recession tend to invest more in innovation. Sun et al. show that government R&D funds stimulate enterprises to increase investment in R&D funds and human innovation activities, which has a positive impact on the release of enterprise innovation [13]. Zhang et al. verified that technological innovation of high-tech enterprises promotes the growth of enterprise innovation performance, concluded that increasing investment in innovation activities can promote the improvement of enterprise innovation performance [14].

H5: Enterprise innovation behavior has a positive impact on enterprise innovation performance.

### 2.4 The Mediating Effect of Firm Innovation Behavior

The innovation behavior of an enterprise is not necessarily reflected in the innovation of products, production processes and production procedures. Enterprise innovation

is reflected in the recombination of production factors, new production and operation modes, new markets, new products, new processes and methods, and new organizational relations.

Sa et al. found that enterprise innovation behavior is significantly positively correlated with enterprise innovation performance [15]. Zhang et al. constructed the PVAR model and analyzed the impact of organizational innovation on innovation. The results show that the government invests a lot of money to help enterprises to innovate, and guides the direction of enterprises' research and development and promotes the improvement of enterprises' innovation ability through government R&D funds and investment in enterprises' innovation [16].

H6: Enterprise innovation behavior plays a mediating role in the relationship between government direct R&D funding and enterprise innovation performance.
H7: Firm innovation behavior plays a mediating role in the relationship between government indirect R&D funding and firm innovation performance.

## 3 Variable Selection and Data Sources

### 3.1 Variable Selection

#### 3.1.1 Dependent Variable

The dependent variable of this paper is enterprise innovation performance. Innovation performance is the product index obtained after the company carries out R&D innovation activities. Innovation performance is the product index obtained after the company carries out R&D innovation activities. This paper uses the number of authorized patents of high-tech enterprises and takes them as natural logarithm to evaluate the innovation performance of enterprises.

#### 3.1.2 Independent Variable

The dependent variable of this paper is government R&D subsidy, which is divided into direct government subsidy (DGRF) and direct government R&D funding (GIRF).

For variables of direct government subsidies (DGRF), the measurement index adopted in this paper is "government subsidy amount". To avoid the hetero scedasticity, logarithmic processing of government subsidy amounts. Government indirect government indirect R&D funding (GIRF), this paper uses the calculation results of the following formula as the measurement index of government indirect R&D funding:

Government indirect R&D funding = tax rebate received/(tax rebate actually paid + tax rebate received).

#### 3.1.3 Intervening Variable

The mediating variable of this paper is firm innovation behavior (INBE). Based on sample data accessibility and validity, this paper adopts the practice of most domestic scholars and takes the proportion of R&D investment in business revenue as an index to measure innovation behavior of enterprises.

**Table 1.** Variable definition table

| Variable name | Variable symbol | Calculation method |
|---|---|---|
| Enterprise innovation performance | INNO | Number of patents granted by the enterprise |
| Direct government R&D funding | DGRF | The natural log of government subsidies |
| Government indirect R&D funding | GIRF | Tax refund received/(tax actually paid + tax refund received) |
| Enterprise innovation behavior | INBE | R&D as a percentage of revenue |
| Enterprise age | AGE | Number of years of establishment |
| Asset-liability ratio | LEV | Total liabilities/total assets |
| Fixed asset ratio | FAR | Sample current period ending fixed assets/ending assets |
| Research and development personnel | R&D Staff | Number of R&D personnel |
| Current ratio | CR | Current assets/current liabilities |

#### 3.1.4 Control Variables

This article sets the control variables, including enterprise size (SIZE), asset-liability ratio (LEV), research and development personnel (R&D Staff), enterprise age (YEAR), fixed assets ratio (FAR), current ratio (CR). Specific variable definitions are shown in Table 1.

### 3.2 Data Sources

Based on the previous research sample selection methods of high-tech listed companies by scholars, this paper selects the data published by enterprises from 2015 to 2020.Considering that there is a certain lag time for enterprises to obtain output after R&D investment, the effect of the input is difficult to be reflected in the current period, so the data used in the variable of innovation performance in this paper are the data from 2016 to 2020, the remaining data are all from 2015 to 2019. The data used in this paper were searched in the database of GTAI' an, and some missing data were manually adjusted in the company's annual report.

### 3.3 Model Building

In order to analyze the impact of government R&D funding on high-tech enterprises' innovation performance, and test whether enterprises' innovation behavior plays a mediating role between government R&D funding and enterprises' innovation performance, based on the above theories and literature analysis, the following model is constructed.

Hypothesis 1 and 2 study the influence of two ways of government R&D funding on innovation behavior of high-tech enterprises, corresponding models are as follows:

$$INNO_{i,t} = \alpha_1 + \beta_1 DGRF_{i,t} + \lambda \sum control_{i,t} + \varepsilon$$

$$\mathrm{INNO}_{i,t} = \alpha_2 + \beta_2 \mathrm{GIRF}_{i,t} + \lambda \sum \mathrm{control}_{i,t} + \varepsilon$$

Hypothesis 3 and 4 study the influence of two kinds of government R&D funding on the company's innovation performance, and hypothesis 5 studies the influence of the company's innovation behavior on the innovation performance of high-tech enterprises. Since the acquisition and output of innovation investment of high-tech enterprises have a lag, this paper selects the lag phase, corresponding to the following model:

$$\mathrm{INNO}_{i,t+1} = \alpha_3 + \beta_3 DGRF_{i,t} + \lambda \sum \mathrm{control}_{i,t} + \varepsilon$$

$$\mathrm{INNO}_{i,t+1} = \alpha_4 + \beta_4 \mathrm{GIRF}_{i,t} + \lambda \sum \mathrm{control}_{i,t} + \varepsilon$$

$$\mathrm{INNO}_{i,t+1} = \alpha_5 + \beta_5 \mathrm{INBE}_{i,t} + \lambda \sum \mathrm{control}_{i,t} + \varepsilon$$

Hypothesis 6 tests the mediating effect of enterprise innovation behavior between direct government R&D funding and enterprise innovation performance, which is also treated with a lag of 1 period, corresponding to the following model:

$$\mathrm{INBE}_{i,t+1} = \alpha_6 + \beta_6 \mathrm{DGRF}_{i,t} + \lambda \sum \mathrm{control}_{i,t} + \varepsilon$$

$$\mathrm{INNO}_{i,t+1} = \alpha_7 + \beta_7 \mathrm{DGRF}_{i,t} + \beta_8 INBE_{i,t} + \lambda \sum \mathrm{control}_{i,t} + \varepsilon$$

Hypothesis 7 tests the mediating effect of enterprise innovation behavior between government indirect R&D funding on enterprise innovation performance. Following model is also established with a lag of 1 period:

$$\mathrm{INBE}_{i,t+1} = \alpha_8 + \beta_9 \mathrm{GIRF}_{i,t} + \lambda \sum \mathrm{control}_{i,t} + \varepsilon$$

$$\mathrm{INNO}_{i,t+1} = \alpha_9 + \beta_{10} \mathrm{GIRF}_{i,t} + \beta_{11} \mathrm{INBE}_{i,t} + \lambda \sum \mathrm{control}_{i,t} + \varepsilon$$

In the equation, The subscript i in the equation represents the i–the enterprise (i = 1, 2, 3…), the sub index t represents the year, in which t = 1 represents 2013, and the rest of the year is analogy, α1-α9 represents the intercept term, β1–β11 is the influence coefficient, λ represents the coefficient of the control variable, control represents the control variable, ε represents the error term.

## 4 Empirical Analysis

### 4.1 Descriptive Statistics

It can be found from the descriptive statistical analysis in Table 2, the difference between maximum value and minimum value of enterprise innovation behavior and enterprise innovation performance is prominent, indicating that there are great differences in innovation input and innovation output among different enterprises.

**Table 2.** Descriptive statistics of variables

| variable | N | Mean | Sd | min | max |
|---|---|---|---|---|---|
| inno | 3055 | 2.951 | 1.268 | 0 | 6.441 |
| dgrf | 3055 | 16.78 | 1.360 | 13.05 | 20.62 |
| girf | 3055 | 0.210 | 0.195 | 0 | 0.830 |
| inbe | 3055 | 5.653 | 4.166 | 0.500 | 24.63 |
| size | 3055 | 22.20 | 1.066 | 20.12 | 25.38 |
| lev | 3055 | 0.385 | 0.179 | 0.0610 | 0.782 |
| rdstaff | 3055 | 5.895 | 1.069 | 3.555 | 9.084 |
| age | 3055 | 2.875 | 0.276 | 2.197 | 3.497 |
| far | 3055 | 0.334 | 0.219 | 0.0190 | 1.094 |
| cr | 3055 | 2.466 | 2.043 | 0.501 | 12.85 |

The standard deviation of innovation performance (INNO) is 1.268, the mean value is 2.951, the maximum value is 6.441, and the minimum value is 0, indicating that the innovation performance of high-tech enterprises varies greatly, but the overall level is high. The maximum value and minimum value of direct government R&D funding (DGRF) and government indirect R&D funding (GIRF) differ greatly, indicating that different high-tech enterprises have received a great difference in the degree of government indirect subsidy; Among the control variables, the number of R&D personnel, liquidity ratio and fixed assets ratio are not evenly distributed, indicating that different enterprises have different operating conditions.

### 4.2 Correlation Analysis

Stata16.0 was used to conduct correlation analysis on each major variable used in the paper. Table 2 shows the results of correlation analysis. The results are shown in Table 3. The correlation coefficient between variables selected in this paper is lower than 0.5 on the whole, indicating that there is no significant linear correlation between variables. To build an innovation-oriented country, enterprises must be strengthened in technological innovation. Because of market failure, the government intervenes in innovation activities. Has become to improve the economic efficiency of enterprises, improve social economic efficiency second choice. Use regression analysis to test the direct effect between variables.

### 4.3 Regression Analysis

(1) Model 1 and 2 take enterprise innovation behavior (INBE) as the explanatory variable, and direct government R&D funding (DGRF) and government indirect R&D funding (GIRF) as the explanatory variable, and conduct regression analysis to explain hypothesis 1 and 2.

**Table 3.** Correlation analysis of each variable

| | inno | dgrf | girf | inbe | size | lev | rdstaff | age | far | cr |
|---|---|---|---|---|---|---|---|---|---|---|
| inno | 1 | | | | | | | | | |
| dgrf | 0.441*** | 1 | | | | | | | | |
| girf | −0.0080 | 0.068*** | 1 | | | | | | | |
| inbe | 0.088*** | 0.085*** | 0.075*** | 1 | | | | | | |
| size | 0.441*** | 0.670*** | −0.0160 | −0.179*** | 1 | | | | | |
| lev | 0.196*** | 0.312*** | 0.00600 | −0.240*** | 0.511*** | 1 | | | | |
| rdstaff | 0.441*** | 0.635*** | 0.095*** | 0.099*** | 0.713*** | 0.311*** | 1 | | | |
| age | 0.175*** | 0.145*** | −0.053*** | −0.098*** | 0.239*** | 0.091*** | 0.163*** | 1 | | |
| far | 0.00500 | −0.0210 | 0.076*** | −0.241*** | 0.083*** | 0.058*** | −0.00300 | 0.148*** | 1 | |
| Cr | −0.111*** | −0.245*** | −0.0280 | 0.227*** | −0.357*** | −0.628*** | −0.264*** | −0.077*** | −0.145*** | 1 |

Note: ***, ** and * represent significant at the level of 1%, 5% and 10% respectively; same below

The analysis shows that the coefficients of government R&D funding are 0.761 and 0.794 respectively, which are significant at the level of 1% and 5%.This indicates that the more subsidies an enterprise receives, the more innovative behaviors it will engage in, which confirms hypothesis 1 and 2.

(2) Model 3 and model 4 take enterprise innovation performance (INNO) as the explanatory variable, and direct government R&D funding (DGRF) and government indirect R&D funding (GIRF) as the explanatory variable. Through regression analysis, the coefficient of government direct R&D funding and indirect funding is 0.208 and 0.268 respectively, which is significant at 1% level. It shows that government R&D funding has a positive effect on firm innovation performance, which confirms hypothesis 3 and 4.

(3) The coefficients of INBE, DGRF and GIRF were 0.761 and 0.794 respectively, which were significant at 1% and 5%; then, taking enterprise innovation performance as the explained variable, the mediating variable enterprise in novation behavior (INBE) is introduced. Through regression analysis, it is found that the regression coefficients of direct government R&D funding (DGRF), government indirect R&D funding (GIRF) and enterprise innovation behavior (INBE) are 0.185, 0.292 and 0.030, respectively, which are all significant at the 1% level, indicating that enterprise innovation behavior It can play a mediating effect and test hypotheses 5, 6 and 7. The results of the regression analysis are shown in Table 4. From the mediation effect analysis, we find that the effect of government R&D funding on the innovation performance of high-tech enterprises is also through the innovation behavior of high-tech enterprises.

**Table 4.** Model regression results

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | inbe | inno | inno | inbe |
| dgrf | 0.761*** | 0.208*** | 0.185*** | 0.761*** |
| | (11.47) | (9.91) | (8.66) | (11.47) |
| girf | 0.794** | 0.268*** | 0.292*** | 0.794** |
| | (2.42) | (2.58) | (2.82) | (2.42) |
| inbe | | | 0.030*** | |
| | | | (5.31) | |
| size | −2.136*** | 0.147*** | 0.211*** | −2.136*** |
| | (−20.56) | (4.47) | (6.06) | (−20.56) |
| lev | −2.223*** | 0.419** | 0.487*** | −2.223*** |
| | (−4.16) | (2.48) | (2.89) | (−4.16) |
| rdstaff | 1.574*** | 0.238*** | 0.190*** | 1.574*** |
| | (17.70) | (8.45) | (6.46) | (17.70) |
| age | −0.660*** | 0.276*** | 0.296*** | −0.660*** |
| | (−2.69) | (3.56) | (3.83) | (−2.69) |
| far | −3.627*** | 0.018 | 0.128 | −3.627*** |
| | (−12.15) | (0.19) | (1.33) | (−12.15) |
| cr | 0.318*** | 0.066*** | 0.056*** | 0.318*** |
| | (7.24) | | (4.03) | (7.24) |

## 5 Conclusions

This paper uses technology innovation theory, tax incentive theory, market failure and government intervention theory as theoretical basis, this paper classifies the research status of domestic and foreign scholars on the relationship between government R&D funding and enterprise innovation performance, the concepts of high-tech enterprise, government R&D subsidy and enterprise innovation behavior are also introduced. On the basis of statistical and empirical analysis of selected data, this paper discusses the promotion effect of government R&D funding on innovation performance of high-tech enterprises. The results show that: (1) government subsidy has a positive effect on innovation performance of high-tech enterprises; (2) The government R&D funding promotes the innovation performance of high-tech enterprises through the investment of R&D funds.

In a word, both direct subsidies from the government and indirect subsidies such as preferential tax policies play an indispensable role in the R&D and innovation activities of high-tech enterprises. Based on previous studies, this paper analyzes the relationship between government R&D funding and innovation performance of high-tech enterprises.

Although the final conclusion is verified by macro enterprise data. However, it lacks the support of microscopic investigation data, which is also one of the follow-up research directions of this paper.

## 6 Policy Suggestions

(1) Increase subsidies for high-tech enterprises, improve subsidy policies, and establish a sound innovation performance evaluation system. High-tech high - tech enterprises are the leaders in China's technological innovation, promoting economic development, the national defense strength, talent competitiveness and science and technology investment have significantly improved the technology group.
(2) Improve the intellectual property protection system and improve the innovation incentive effect of government subsidies. Improving the intellectual property protection system can not only directly promote enterprises to carry out innovation activities, but also strengthen the incentive effect of government subsidies and improve the efficiency of government subsidies. Therefore, from the legislative level, we can further improve the laws and regulations of intellectual property protection, improve their operability, and give full play to the incentive effect of government subsidies. In the law enforcement, it is necessary to strengthen the punishment of intellectual property infringement and reduce the probability of infringement.
(3) The government should strengthen the supervision of subsidy funds, not only ensure the quantity of innovation subsidies, but also improve the quality of subsidies, to ensure that enterprises use government subsidies for research and development, and effectively promote the improvement of enterprise innovation performance. Clarify the classification and scope of use of government subsidies, strengthen the post-evaluation of government subsidies, improving effectiveness of government subsidies.

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