The Effect of Tax Credits for R&D Expenditure Policy on Firms R&D Expenditure ——A Comparison Perspective of Policy Tool

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ABSTRACT

This paper investigates the analysis model of crowding in and out for tax credits for R&D expenditure to firms' R&D expenditure. Based on enterprises above designated size in Dalian, the different effects of fiscal technology investment funds, high-tech enterprise tax reduction and tax credits for R&D expenditure policies on corporate R&D internal and external expenditures based on Agosin and Mayer (2005)'s model are compared and analyzed. The results show that among the three policy instruments, the tax credits for R&D expenditure policy has the strongest impact on the internal and total R&D expenditure, while the combined impact of the other two policy instruments is weakened. The impact of tax credits for R&D expenditure on firm internal expenditures is not significant. Tax credits policy exerts the weakest crowding out effect on R&D expenditures of enterprises.

Keywords: *Tax credits policy, internal and external R&D expenditure, crowding-in and crowding-out effects*

1. INTRODUCTION

In 2018, China's R&D expenditure is expected to account for 2.15% of GDP, and the total number of researchers will reach 4,180,000, science and technology having witnessed considerable development. In order to achieve the goal of becoming an innovation-oriented country by 2020, Chinese government shall carry out precise policies aiming at mobilizing people's enthusiasm and optimizing allocation of resources, strengthening the implementation of existing policies, and further releasing the vitality and creativity of scientific and technological talents. In recent years, to implement innovation-driven development strategies and encourage firms to invest more in R&D, the government has utilized a series of policy tools to encourage firms on R&D and innovation, among which the implementation of the tax credits for R&D expenditure policy has been intensified with the fastest growth rate [1]. Then, can tax credits for R&D expenditure promote firms' R&D expenditure and effectively activate their creativity? What are the advantages and disadvantages compared with other policy tools? Answering the above questions is of practical significance in enriching policy tools theory and supporting public policy making.

It's not hard to see that academia has conducted extensive and in-depth researches on the relationship between different policy tools and firms' R&D expenditure. First, policy support from the government has an inductive effect on firms' R&D expenditure. Zhu and Xu [2] analyzed that both government science and technology funding and tax reduction have a positive impact on firms' R&D investment, and the degree of stability of government grants has obviously positive correlation with R&D investment. The empirical study of Xu and Shi [3] also supports that government funding is beneficial to firms' R&D expenditure. Besides, Czarnitzki and Toole [4] found that government R&D subsidies can mitigate market uncertainty, and then increase firms' R&D expenditure. Jiang and Qi [5] argue that tax policy has a practical incentive effect on the increase of R&D expenditure of high-tech enterprises in Beijing Zhongguan Science and Technology Park. Others such as Yang [6] used the data of manufacturing enterprises in Taiwan to find that tax incentives can promote firms' R&D expenditure. Kang and Park [7] have also found that project funds supported by government can induce enterprises to raise internal R&D expenditure. Research conducted by Guo and his copartners [8] pointed out that government's R&D funding to enterprises would leverage their R&D investment, of which this effect would grow with the process of industrialization.

Second, government policy support has a "crowding-out effect" on firms' R&D expenditure. Wu [9] has found that the effect of Chinese tax credit policy is not obvious, and the incentive effect on enterprises' R&D investment is limited. Based on Irish manufacturing data, GÖRG and STROBL [10] believed that government R&D funding had a certain degree of crowding-out effect on firms' R&D investment, and reduced R&D level of the whole industry. Marino's team argues that government tax preference at the medium and high level has a more pronounced crowding-out effect on firms' R&D expenditure [11].

Third, the relationship between government policy and firms' R&D expenditure is not linear. Hu and Zhou [12] provide evidence that government direct subsidies can facilitate enterprises' spending on technological innovation, which varies with the change of total amount of subsidies, showing a momentum of increasing first and then decreasing. Lee [13] studied data of different industries in many countries and found that government support for R&D had an inductive effect on enterprises with low technical ability and intense market competition, while it had a crowding-out effect on those with high technical ability and low market competition pressure. Dai and Cheng [14] believed that although financial aid can generally promote firms' R&D investment, there is a threshold effect that government subsidy will have a negative impact on it if exceeding a certain critical value. Becker [15] also confirmed that there is an "inverted U shape" relationship between government subsidy and firms' R&D investment, and stated that providing appropriate subsidies to more enterprises is more beneficial to enterprises to invest in R&D than giving a large amount of subsidies to a few enterprises. Yu and Jiang [16] found that there was a regional gap in the influence of public R&D investment on enterprises R&D, and the degree of support from different public R&D departments would also affect that of enterprises.

expenditure is primarily focused on government fiscal technology investment funds and high-tech enterprises tax

To sum up, the current research on the relationship between government policy tools and firms' R&D reduction, which doesn't reach a consent. There is still room for further research. First, the main consider of existing research is financial support and tax reduction, rarely relating to tax credits for R&D expenditure. In fact, tax credits for R&D expenditure developed fastest in recent years and it is urgent to evaluate its effect. Second, due to the availability of data, existing research mainly takes industry enterprise as a sample. Against the background China, government fiscal and tax policy tools are mainly implemented by cities, and there is a significant urban effect on R&D investment of enterprises [17]. Therefore, this paper proposes to establish a model of the effect of tax credits for R&D expenditure policy on firms' internal and external R&D expenditure, compares it with government fiscal technology investment funds and high-tech enterprises tax reduction, conducts empirical tests based on enterprises above designated size in Dalian and studies differences between the implementation of different policy tools on firms' R&D expenditure, providing policy proposals for policy tool selection and implementation.

2. RESEARCH DESIGN

As a tool of tax reduction, tax credits for R&D expenditure can lower tax base of enterprises, reduce total volume of enterprises taxes, indirectly encourage firms' R&D investment and reduce risks and capital constraint of enterprise R&D investment.

As the most direct incentive method, financial support from government fiscal technology investment funds and supplements R&D fund are provided for specific firms and projects, which rapidly increased firms' R&D expenditure. High-tech enterprises tax reduction is to apply preferential taxation policy for high-tech enterprises with strong support from the nation, reduce R&D risks of high-tech enterprises and improve their production efficiency. Compared with the former two, tax credits for R&D expenditure policy targets towards enterprises that conduct R&D activity. With the purpose of guide and encourage firms to actively carry out R&D, its universality is most significant.

2.1. Research Model

The existing research are mainly based on multiple linear regression, threshold model and other methods to study the effects of government policy tools and explore the direct effect of policy tools on firms' R&D expenditure variable. In fact, the expenditure itself is affected by various policy tools, as well as other factors, such as enterprises and industries. Therefore, on the basis of an analytical model proposed and optimized by Agosin and Mayer [18], Liu and Sun [19], this paper proposes a regression model for analyzing crowding-in effects and crowding-out effects of firms' R&D expenditure by different policy tools. The modelling process is as follows:

Firms' R&D expenditure is co-affected by many variables, and government policy is only one of them. Analysis of the influence of government R&D policy on firms' R&D expenditure may start from basic function model, as shown in formula (1), namely firms' R&D expenditure (RI) is equal to government R&D policy support (GRP) plus other factors (OF):

$$RI = GRP + OF \qquad (1)$$

Formula (1) assumes that policy tool does not generate externality on firms' R&D expenditure, namely each unit of change in policy tool is followed by a unit of change in firms' R&D expenditure. Then develop formula (1), that is to add a coefficient which can be positive or negative before the variable GRP, further modelling other factors, and the variable is logarithmically processed to obtain formula (2).In formula (2), Z represents other factors affecting firms' R&D expenditure, and α represents fixed effect of other factors.

$$lnRI = \alpha + \beta_1 lnGRP + \beta_2 Z \qquad (2)$$

In the consideration of hysteresis and inertia of enterprises R&D activity, R&D expenditure in t-1th year will affect that of its tth year [20]. So, based on formula (2), the time factor is added, as well as lagged explanatory variable, and then extend (2) to formula (3), in which ε is a residual term.

$$ln\mathrm{RI}_t = \alpha + \beta_i lnGRP_t + \beta_j lnRI_{t-1} + \beta_h Z + \varepsilon \qquad (3)$$

In the study of crowding-in effects and crowding-out effects, when firms' R&D expenditure decreases along with the increase of government policy tool support, it is considered that the government policy has a crowding-out effect on firms' R&D expenditure; otherwise, a crowding-in effect[6] will be reflected. This paper is based on Agosin and Mayer (2000) model to determine whether it shows a crowding-out effect or a crowding-in effect in the long term by examining the following long-term reaction coefficients:

$$\hat{\beta} = \frac{\sum_{i=1}^{n} \hat{\beta}_i}{1-\hat{\beta}_j} \quad (4)$$

Using Wald test, if the assumption of $\hat{\boldsymbol{\beta}}$=1 is accepted, it indicates that there is neither a crowding-out effect nor a crowding-in effect, and an increase of one unit of $\boldsymbol{GRP}$ leads to an increase of one unit of firms' R&D expenditure. If the assumption of $\hat{\boldsymbol{\beta}}$>1 is accepted, it shows that there is a crowding-in effect, and the increase of one unit of $\boldsymbol{GRP}$ causes firms' R&D expenditure to increase more than one unit. If the assumption of $\hat{\boldsymbol{\beta}}$<1 is accepted, it reveals that there is a crowding-out effect, and the increase of one 2.2. Variables and Measurement

In this paper, government policy tools and different types of firms' R&D expenditure are used as explanatory variable and explained variable respectively for the estimation of regression model (see Table 1).

2.2.1. Explained variable

Firms' R&D expenditure can be further divided into internal and external one. The former mainly refers to the funds provided by the enterprise for its R&D activities carried out internally, which means it researches and develops independently by its own technical department and R&D center. And external R&D expenditure is the funds that firms offer for cooperation and R&D with research institutions and other enterprises, accounting for firms' cooperation and innovation with advantages of other effectively through research institutions. There are three types of explained variable in this article: firms' total R&D expenditure, firms' internal R&D expenditure and firms' external R&D expenditure. Here measures logarithms of the number of internal R&D expenditure, of external R&D expenditure and the sum of these two. And high-tech enterprises tax reduction (GRP_3) refers to that of income for enterprises recognized as national high-tech enterprises. The model can be further developed as:

$$lnRI_t = \alpha_1 + \beta_1 lnGRP_{1t} + \beta_2 lnGRP_{2t} + \beta_3 lnGRP_{3t} + \beta_4 lnRI_{t-1} + \beta_5 Z_1 + \beta_6 Z_2 + \beta_7 Z_3 + \beta_8 Z_4 + \varepsilon_1 \quad (8)$$

$$lnIRI_t = \alpha_2 + \beta_1 lnGRP_{1t} + \beta_2 lnGRP_{2t} + \beta_3 lnGRP_{3t} + \beta_4 lnRI_{t-1} + \beta_5 Z_1 + \beta_6 Z_2 + \beta_7 Z_3 + \beta_8 Z_4 + \varepsilon_2 \quad (9)$$

$$lnERI_t = \alpha_3 + \beta_1 lnGRP_{1t} + \beta_2 lnGRP_{2t} + \beta_3 lnGRP_{3t} + \beta_4 lnRI_{t-1} + \beta_5 Z_1 + \beta_6 Z_2 + \beta_7 Z_3 + \beta_8 Z_4 + \varepsilon_3 \quad (10)$$

2.2.2. Explanatory variable

The variables of government policy tools include tax credits for R&D expenditure, government fiscal technology investment funds and high-tech enterprises tax reduction. Tax credits for R&D expenditure is a tax preferential policy that according to taxation regulations, adds a certain proportion to actual costs of R&D expenditure on developing new technologies, new products and new crafts, which is implemented as tax deduction when calculating taxable income. This paper will measure the logarithm of the amount of tax credits for R&D expenditure. Government R&D investment policy refers to monetary assets directly obtained by enterprises from government for free and here the authors will use the logarithm of the total amount of various government subsidies to engage in measurement. High-tech enterprises tax reduction policy means that high-tech enterprises with recognition can apply for a 15% tax rate for the collection of enterprise income taxes under the relevant provisions. And this paper evaluates the logarithm of the amount of high-tech enterprises tax relief.

2.2.3. Control variable

In order to control other factors of firms' R&D expenditure, this paper introduces variables, like enterprise age, firm size, the number of valid patents for invention, and enterprises share holdings. Enterprise age is the time period from the establishment of an enterprise to the year of data collection, which is related to the length of time an enterprise enters a market and can affect firms' R&D expenditure. Firm size refers to systematic differences between enterprises of different sizes that will affect their innovation behaviour and effects of government subsidies, therefore, this paper divides firms into four categories, large, medium, small and micro. The number of valid patents for invention to some extent reflects enterprise innovative capacity. The larger the number is, the stronger innovative capacity of the enterprises. Enterprise holding: systems and institutions have different

2.3. Sample and Data

This article takes enterprises above designated size in Dalian from 2012 to 2016 as research samples, explores crowding-in effects and crowding-out effects of tax credits for R&D expenditure policy on firms' R&D expenditure, meanwhile, contrasts and analyses differences in the effects of different government policy tools on R&D expenditures. Among enterprises above designated size, some must reach a certain output scale that can meet the national requirements on environmental protection, energy consumption, health and safety, etc., with cost advantages as well. The selection of enterprises above designated size in Dalian as research objects is mainly based on the following aspects. First, enterprises above designated size are core strength of Chinese national economic development and technological innovation, which play a significant role in national strategy of innovation-driven development. Second, high-tech enterprises should be representative that account for the majority of the mentioned enterprises with the large number of enterprises with R&D expenditure and enjoying government preferential policies and subsidies in order to better reflect the research of this paper. Third, information disclosure of these enterprises is complete and easy to obtain. This paper selects 554 pieces of unbalanced panel data of 143 enterprises above designated size in Dalian from

2012 to 2016, of which the related data are collected from Dalian Technology Bureau and Dalian Bureau of Statistics.

Table 1 Variables and measurement

Variable Types	Variable Names and Symbols	Measurement
Dependent Variable	Firms' Internal R&D Expenditure *(IRI)*	Logarithm of Internal R&D Expenditure
	Firms' External R&D Expenditure *(ERI)*	Logarithm of External R&D Expenditure
	Firms' Total R&D Expenditure *(RI)*	Logarithm of Internal and External R&D Expenditure
Independent Variable	Tax Credits for R&D Expenditure (GRP_1)	Logarithm of the Amount of Tax Credits for R&D Expenditure
	Government Fiscal Technology Investment Funds (GRP_2)	Logarithm of the Amount of Funds for Science and Technology Activities from Government
	High-tech Enterprises Tax Reduction (GRP_3)	Logarithm of the Amount of High-tech Enterprises Tax Reduction
Control Variable	Enterprise Age *(AGE)*	Number of Years from establishment to 2018
	Firm Size *(SIZE)*	Classification, 1 Large, 2 Medium, 3 Small, 4 Micro
	Number of Valid Patent for Invention *(PAT)*	Number of Valid Patent for Invention Per Year
	Enterprises Share Holdings *(HOLD)*	Classification, 1 Collective Holding, 2 State-owned Holding, 3 Private Holding, 4 Foreign Holding

3. EMPIRICAL STUDY

3.1. Statistical Description and Correlation Analysis

Table 2 shows descriptive statistics and correlation analysis of R&D expenditure of enterprises above designated size. In order to avoid multiple collinearity problems among explanatory variables that may result in deviation of estimated coefficients of explanatory variables, correlation coefficient test among variables were conducted before multiple regressions. In terms of enterprises holdings, private holding enterprises accounted for 69.93% of the samples, state-owned holding for 15.38%, and collective holding and foreign holding for 3.50% and 11.19% respectively. The average life expectancy of enterprises is 23.93 years.

As can be seen from Table 2, the mean value of firms' internal R&D expenditure (m=8.610) is much bigger than that of the external (m=1.705), slightly smaller than total (m=8.661). It indicates that enterprises are mainly inclined to internal R&D, and also explains high correlation between internal and total R&D expenditure. Besides, the correlation between independent and dependent variables is positively correlated, which leads to a preliminary deduction that firms' R&D expenditure is affected by government R&D policies.

According to the result of multiple collinearity test, VIF value is far less than 10, which means that there is no multiple collinearity problem between explanatory variables and explained ones. The test for heteroscedasticity was conducted by White test, and its result reveals that the hypothesis of heteroscedasticity was rejected, namely there is no heteroscedasticity in each model.

3.2. Results of Regression Analysis

In order to further analyze the relationship between different policy tools and firms' R&D expenditure, this paper investigates the effects of different government policy tools on firms' R&D expenditure with other conditions unchanged, and performs a regression analysis of firms' R&D expenditure model. Due to missing data in the course of data-collection, this paper adopts a regression model of unbalanced panel data. The overall characteristic of the sample is a left truncation at the point where the expenditure is equal to zero. If regression of the sample by OLS is taken, it will lead to measurement bias. Therefore, truncated regression is chosen to analyze the sample.

3.2.1. The relationship between tax credits for R&D expenditure and firms' internal R&D expenditure

Table 3 shows the effects of government policy tools on firms' internal R&D expenditure, and Model 1 only considers control variables. It can be seen that internal R&D expenditure is notably influenced by both firm size and the number of valid patents for invention ($\beta = -0.518, \rho < 0.01$). The bigger firm size is, the higher internal R&D expenditure; the larger the number of valid patents for invention is, the more internal R&D expenditure. Compared with private holding and foreign holding enterprises, state-owned enterprises are more inclined to internal R&D expenditure, and enterprise age has no significant effect on firms' internal R&D expenditure.

On the basis of Model 1, Model 2 introduced lagged variable of firms' internal R&D expenditure, and the result indicates that the internal R&D expenditure of the previous year has a significant positive impact on that of this year. Model 3 to

Model 6 introduced R&D policy tools respectively, namely tax credits for R&D expenditure, government fiscal technology investment funds and high-tech enterprises tax reduction. The results demonstrate that tax credits for R&D expenditure has the same positive effect on firms' internal R&D expenditure as the other two policy tools ($\beta = 0.126, \rho < 0.01$; $\beta = 0.113, \rho < 0.01$; $\beta = 0.093, \rho < 0.01$). Specifically, tax credits for R&D expenditure in smallest overall size has the largest incentive effect, while high-tech enterprises tax reduction in smallest overall size has the least incentive effect than the other two. When Model 6 introduced three independent variables at the same time, it is found that the positive effect of the three on internal R&D expenditure still remains significant, but the effect of tax credits for R&D expenditure is declining. And government fiscal technology investment funds have the most remarkable effect on internal R&D expenditure, each additional 1% of the funds leading to the increasing 0.1% of firms' internal R&D expenditure.

3.2.2. The relationship between tax credits for R&D expenditure and firms' external R&D expenditure

Table 4 reveals regression results of three types of government policy tools and firms' external R&D expenditure. In Model 7, only the number of valid patents for invention has a significant positive effect on external R&D expenditure ($\beta = 0.013$, $\rho < 0.01$), but firm size and state-owned holding enterprises do not. And in Model 9 to Model 12, tax credits for R&D expenditure has no significant effect on firms' external R&D expenditure, while high-tech enterprises tax reduction exerts a marked positive impact ($\beta = 0.100$, $\rho < 0.01$). No significant effect of tax credits for R&D expenditure on external R&D expenditure illustrates that this policy does not encourage enterprises to outsource R&D activity. Furthermore, foreign holding enterprises have an obvious negative impact on firms' external R&D expenditure ($\beta = -2.042$, $\rho < 0.05$). In the samples, external R&D expenditure accounts for 19.62% of the total expenditure of firms, a relatively small share, which may influence the empirical results of factors affecting firms' external R&D expenditure.

3.2.3. The relationship between tax credits for R&D expenditure and firms' total R&D expenditure

The conclusion of Table 5 basically comes to an agreement with Table 3. It shows that firms' total R&D expenditure of the previous year has a significant positive impact on that of this year ($\beta = 0.169$, $\rho < 0.01$); Internal R&D expenditure is remarkably influenced by both firm size and the number of valid patent for invention; in line with the other two policy tools, tax credits for R&D expenditure is also conducive to total R&D expenditure and even has the most significant effect. Model 18 indicates that when the three government policy tools simultaneously exist, tax credits for R&D expenditure policy is weakening, and government fiscal technology investment funds have the most significant effect on total R&D expenditure, each additional 1% of the funds increasing 0.092 % of firms' total R&D expenditure. Model 13 to Model 18 reveal that the impact of state-owned holding enterprises on total R&D expenditure is significantly greater than that of private holding and foreign holding enterprises.

3.3. Analysis on Crowding-in Effects and Crowding-out Effects

The value of $\hat{\beta}$ is calculated according to formula (4), and the result is shown in Table 6 to analyze crowding-in effects and crowding-out effects of government R&D policy tools. As can be seen from Table 6, since tax credits for R&D expenditure and fiscal technology investment funds have no significant effect on firms' external R&D expenditure, there is no crowding-in or crowding-out effects. In general, in accordance with other R&D policy tools, there is crowding-out effect of tax credits for R&D expenditure on firms' R&D expenditure, namely each unit of increase in the logarithm of government R&D policy causes R&D expenditure increase less than one unit. By contrast, tax credits for R&D expenditure policy has the weakest crowding-out effect, each additional unit of the logarithm of tax credits for R&D expenditure bringing an increase of 0.145 unit of the logarithm of total R&D expenditure, crowding out 0.855 unit. While high-tech enterprises tax reduction policy has the most significant crowding-out effect on firms' R&D expenditure, each additional unit of the logarithm of high-tech enterprises tax reduction producing an increase of 0.11 unit of the logarithm of firms' total R&D expenditure, crowding out 0.89 unit. Overall, if tax credits for R&D expenditure policy is used in coordination with other two policies, the crowding-out effects will be dramatically reduced.

Table 2 Descriptive statistics and partial correlation analysis

Variables	Average	Standard	Minimum	Maximum	1	2	3	4	5	6	7	8
1. *IRI*	8.610	1.855	0	14.318	1.000							
2.	1.705	3.161	0	11.499	0.435***	1.000						

Variables	Average	Standard	Minimum	Maximum	1	2	3	4	5	6	7	8
ERI												
3. RI	8.661	1.840	0.693	14.376	0.992***	0.490***	1.000					
4. GRP_1	1.464	3.040	0	12.353	0.414***	0.379***	0.415***	1.000				
5. GRP_2	2.574	3.441	0	11.623	0.361***	0.291***	0.354***	0.334***	1.000			
6. GRP_3	1.973	3.379	0	11.927	0.365***	0.323***	0.370***	0.569***	0.182***	1.000		
7. *AGE*	23.934	19.820	4	139	0.104**	0.131***	0.108**	0.106**	0.077*	0.038	1.000	
8. *SIZE*	2.814	0.971	1	4	-0.417***	-0.301***	-0.431***	-0.191***	-0.036***	-0.154***	-0.064	1.000
9. *PAT*	12.579	30.502	0	416	0.404***	0.353***	0.406***	0.319***	0.235***	0.270***	0.019	-0.252***

Note: Significance level ***p<0.01, **p<0.05, *p<0.

Table 3 Regression results of different public policies and firms' intramural expenditure on R&D

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
GRP_1			0.126***			0.069**
GRP_2				0.113***		0.100***
GRP_3					0.093***	0.059**
IRI_{t-1}		0.173***	0.155***	0.161***	0.156***	0.142***
AGE	0.003	0.005	0.003	0.003	0.004	0.001
SIZE	-0.518***	-0.429***	-0.407***	-0.450***	-0417***	-0.428***
PAT	0.016***	0.014***	0.011***	0.012***	0.012***	0.009***
Hold- State	1.128***	0.929***	0.830**	0.775**	0.933***	0.740**
Hold- private	-0.105	-0.496	-0.365	-0.485	-0.445	-0.382
Hold- foreign	-0.155	-0.396	-0.233	-0.231	-0.340	-0.124
Constant	9.773***	8.309***	8.216***	8.240***	8.250***	8.821***
sigma	1.475***	1.457***	1.415***	1.411***	1.426***	1.362***
Log Likelihood	-981.615	-658.912	-648.0.83	-647.028	-651.049	-636.740
Wald chi2	281.10	200.57	235.07	238.54	225.42	273.46

Note: Significance level ***p<0.01, **p<0.05, *p<0.1

Table 4 Regression results of different public policies and firms' external expenditure on R&D

Variables	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
GRP_1			0.032			-0.029
GRP_2				-0.038		-0.040
GRP_3					0.100**	0.117**
ERI_{t-1}		0.077	0.072	0.078	0.058	0.060
AGE	-0.001	-0.001	-0.002	0.001	-0.003	-0.001
SIZE	-0.161	-0.133	-0.121	-0.138	-0.091	-0.100
PAT	0.013***	0.011***	0.010**	0.011***	0.009**	0.010**
Hold- State	0.473	0.097	0.069	0.112	0.204	0.262
Hold- private	-0.635	-0.865	-0.824	-0.981	-0.852	-1.008
Hold- foreign	-1.057	-1.654*	-1.560	-1.714*	-1.859*	-2.042**
Constant	7.191***	7.298***	7.180***	7.479***	6.953***	7.191***
sigma	1.822***	1.764***	1.760***	1.759***	1.719***	1.710***
Log Likelihood	-270.354	-190.573	-190.355	-190.338	-188.101	-187.632
Wald chi2	42.52	30.16	30.73	30.78	36.79	38.07

Note: Significance level ***p<0.01, **p<0.05, *p<0.1

Table 5 Regression results of different public policies and firms' total expenditure on R&D

Variable	Model 13	Model 14	Model 16	Model 15	Model 17	Model 18
GRP_1			0.123***			0.066**
GRP_2				0.105***		0.092***
GRP_3					0.094***	0.062**
RI_{t-1}		0.169***	0.151***	0.159***	0.152***	0.140***
AGE	0.004	0.006	0.003	0.003	0.004	0.001
SIZE	-0.556***	-0.456***	-0.435***	-0.476***	-0.445***	-0.454***
PAT	0.015***	0.135***	0.011***	0.011***	0.011***	0.009***
Hold- State	1.100***	0.902**	0.806**	0.760**	0.907***	0.727**
Hold- private	-0.233	-0.512*	-0.383	-0.501*	-0.460	-0.400
Hold- foreign	-0.210	-0.470	-0.311	-0.317	-0.413	-0.212
Constant	9.932***	8.502***	8.407***	8.433***	8.441***	8.351***
sigma	1.482***	1.430***	1.389***	1.390***	1.398***	1.350***
Log Likelihood	-985.789	-652.118	-641.369	-641.562	-643.709	-630.867
Wald chi^2	209.32	209.32	244.08	243.44	236.34	280.08

Note: Significance level ***p<0.01, **p<0.05, *p<0.1.

Table 6 The crowding-in effects and crowding-out effects of different public policies on firms' expenditure on R&D

Main Policy Tools	Internal R&D Expenditure *IRI*	External R&D Expenditure *ERI*	Total R&D Expenditure *RI*
Tax Credits for R&D Expenditure GRP_1	0.149	——	0.145
Fiscal Technology Investment Funds GRP_2	0.135	——	0.125
High-tech Enterprises Tax Reduction GRP_3	0.110	0.100	0.110
Overall Government Policy Tools	0.268	0.117	0.258

First of all, tax credits for R&D expenditure policy has a significant positive effect on firms' internal and total R&D expenditure, and its independent impact is greater than that of government R&D investment and high-tech enterprises tax reduction policy, while the comprehensive impact is stronger than high-tech enterprises tax reduction. However, tax credits for R&D expenditure policy has no significant effect on external R&D expenditure, while only high-tech enterprises tax reduction has a significant positive effect on it. Next, tax credits for R&D expenditure policy has a certain crowding-out effect on firms' R&D expenditure, but compared with the other two policy tools, its effect is the weakest. High-tech enterprises tax reduction has the strongest crowding-out effect on R&D expenditure. The overall results indicate that tax credits for R&D expenditure policy is more conducive to promote internal research and development of enterprises than the other two, and crowding-out effect proves weakest by comprehensive implementation of these three policy tools.

Therefore, government should be more pertinent when making policies to encourage R&D investment. Although government policies effectively stimulate firms' R&D expenditure, different policy tools vary in the effects on different types of R&D expenditure. For enterprises with high R&D expenditure, they are supposed to use the said policy tool; specifically, for enterprises mainly relying on independent research and development, they should adopt government fiscal technology investment funds policy to directly inspire their R&D enthusiasm; for these largely depending on external cooperation and R&D, high-tech enterprises tax reduction policy tool is preferred. While considering the incentive effect of government policy tools, it is also necessary to take the crowding-out effect of different policy tools into account. High-tech enterprises tax reduction can encourage firms' external R&D expenditure, but it also engenders a strong crowding-out effect; policy tools have the most significant crowding-out effect on external R&D expenditure. To this end, policy tools should be used deliberately for enterprises with high external R&D expenditure.

REFERENCES

[1] Ma W C, Liao J C., The effects of different ways of public S&T subsidies on private R&D expenditure[J]. Studies in Science of Science, 35(5) (2017) 689-698. DOI, 10.16192/j.cnki.1003-2053.2017.05.006

[2] Zhu F P, Xu W M., On The Impact of Government's S&T Incentive Policy on the R&D input and its patent output of large and medium-sized Industrial enterprises in Shanghai[J]. Economic Research Journal, (6) (2003) 45-53. DOI, cnki.SUN.JJYJ.0.2003.06.005

[3] Xu Z, Shi P., Empirical Analysis on the Impacts of Government' Investment in Science & Technology to the Outlay of Enterprise' R&D[J]. R&D Management,

(3)(2005) 22-26. DOI, 10.13581/j.cnki.rdm.2005.03.005

[4] Czarnitzki D, Toole A A., Business R&D and the interplay of R&D subsidies and product market uncertainty[J]. Review of Industrial Organization, 31(3) (2007)169-181. DOI, 10.1007/s11151-007-9152-x

[5] Jiang J J, Qi J G., The Tax Policy Effect for Promoting Enterprises' R&D Investments[J]. China Soft Science, (8) (2007) 65-70. DOI, 10.3969/j.issn.1002-9753.2007.08.009

[6] Yang C H, Huang C H, Hou T C T., Tax incentives and R&D activity: Firm-level evidence from Taiwan[J]. Research Policy, 41(9) (2012)1578-1588. DOI, https://xs.scihub.ltd/https://doi.org/10.1016/j.respol.2012.04.006

[7] Kang K N, Park H., Influence of government R&D support and inter-firm collaborations on innovation in Korean biotechnology SMEs[J]. Technovation, 32(1) (2012)68-78. DOI, https://doi.org/10.1016/j.technovation.2011.08.004

[8] Guo Y, Gu W, Wu T and Wang L., The Impact of Government Funding on Business R&D Expenditure[J]. China Soft Science, (3)(2016)162-174. DOI, cnki: SUN: ZGRK.0.2016-03-014

[9] Wu X B., Impact of revenue stimulation on R&D investment: Empirical analysis and policy implement selection[J]. R&D Management, 15(1)(2003):36-41. DOI, 10.13581/j.cnki.rdm.2003.01.008

[10] Görg H, Strobl E., The effect of R&D subsidies on private R&D[J]. Economica, 74(294) (2007)215-234. DOI,https://xs.scihub.ltd/https://doi.org/10.1111/j.1468-0335.2006.00547.x

[11] Marino M, Lhuillery S, Parrotta P, et al., Additionality or crowding-out? An overall evaluation of public R&D subsidy on private R&D expenditure[J]. Research Policy, 45(9)(2016)1715-1730. DOI, https://xs.scihub.ltd/https://doi.org/10.1016/j.respol.2016.04.009

[12] Hu Y, Zhou J., A Study of the Relationship between Government R&D Funding and Business Technology Innovation Activities[J]. China Soft Science, (11) (2008)141-148. DOI, CNKI: SUN: ZGRK.0.2008-11-019

[13] Lee C Y., The differential effects of public R&D support on firm R&D: Theory and evidence from multi-country data[J]. Technovation, 31(5-6) (2011)256-269. DOI,https://xs.scihub.ltd/https://doi.org/10.1016/j.technovation.2011.01.006

[14] Dai X. and Cheng L., The threshold effects of fiscal subsidy policy on corporate R&D investment[J]. Science Research Management, 35(06) (2014)68-76. DOI, 10.19571/j.cnki.1000-2995.2014.06.009

[15] Becker B., Public R&D policies and private R&D investment: A survey of the empirical evidence[J]. Journal of Economic Surveys, 29(5) (2015)917-942. DOI,https://xs.schub.ltd/https://doi.org/10.1111/joes.12074

[16] Yu W. and Jiang F., A research on the leverage of public R&D investment on enterprise R&D investment[J]. Studies in Science of Science, 35(01) (2017)85-92. DOI, 10.16192/j.cnki.1003-2053.2017.01.010

[17] Zhang X, and Hao P., Is There a City Effect from Enterprises' R&D Investment? Perspective of Entrepreneurial Vitality[J]. China Soft Science, (3) (2017)110-122. DOI, 10.3969/j.issn.1002-9753.2017.03.012

[18] Agosin M R., Machado R. Foreign investment in developing countries: does it crowd in domestic investment? [J]. Oxford Development Studies, 33(2) (2005)149-162. DOI, https://xs.scihub.ltd/https://doi.org/10.1080/13600810500137749

[19] Liu F, Sun Y., Analysis on the Effect of Governmental S&T Input to Other S&T Input in China [J]. R&D Management, (06)(2007)100-107. DOI, 10.13581/j.cnki.rdm.2007.06.021

[20] Li W, Yu X, Cai L., Study on the relationship between government R&D investment, intellectual property right protection and enterprises R&D investment[J]. Studies in Science of Science, (3) (2016)357-365. DOI, 10.16192/j.cnki.1003-2053.2016.03.005