R&D subsidies, executive background and innovation of Chinese listed companies

Xiuwu Zhang, Lixiang Wang & Feng Chen

Published online: 02 Sep 2020.

Submit your article to this journal ⧉

Article views: 2056

View related articles ⧉

View Crossmark data ⧉

Citing articles: 11 View citing articles ⧉

Routledge
Taylor & Francis Group

R&D subsidies, executive background and innovation of Chinese listed companies

Xiuwu Zhang, Lixiang Wang and Feng Chen

School of Statistics, Huaqiao University, Xiamen, China

ABSTRACT

Enterprises are the mainstay of national innovation. The improvement of enterprise productivity and the sustained and rapid development of the economy are inseparable from the research and development (R&D) and innovation of enterprises. Most previous research studies have focused on the economic system and scale of enterprises to study the impact of government–enterprise relations on corporate innovation. This article takes the heterogeneity background characteristics of executives as the starting point, discusses the internal mechanism of R&D subsidies, the background characteristics of corporate executives and the innovative behaviour of Chinese listed companies, and draws two conclusions: (1) The current Chinese government's innovation subsidy allocation process still has some preferences, such as the company's executives have more R&D subsidies for listed companies with a background in government, technical background and high academic background; and (2) Although the three types of background characteristics of executives are beneficial to the company's R&D subsidies, the government background of executives has not significantly promoted the innovation of listed companies, while the background of technology R&D and high academic background of executives have significantly promoted corporate innovation.

1. Introduction

Innovation has become a key factor in promoting economic development. The universal experience of the world's technologically advanced countries confirms that enterprises are the mainstay of national innovation. In addition to market competitiveness, the government has played an important role in enterprise innovation. Government subsidies policy are needed to overcome the 'failure of innovation'. However, the effectiveness of government R & D subsidies at this stage has been questioned. First, due to the asymmetry of information held by the enterprise and the government, the government cannot understand the complete situation of the

CONTACT Feng Chen ✉ 18013021001@stu.hqu.edu.cn

enterprise, making it difficult for the government to determine which R&D activities can produce the maximum output of the enterprise; The technical capability and technical evaluation system are not transparent, and it is difficult for the government to make the most accurate judgement on the company's R&D capabilities and the technical level of the enterprise. The background of the company's core business executives has a decisive influence on the company's development. Therefore, it is very important to study the moderating role of the background of company executives between government subsidies and the innovative behaviour of listed companies.

R&D subsidies are the most direct and common government-to-business support policies that have been implemented in various countries around the world for a long time. At the same time, the actual effects of R&D subsidies are diverse. At present, the research in this aspect can be divided into two major schools: 'promotion theory' and 'suppression theory'. 'Promoting theory' scholars believe that R&D subsidies can make up for the lack of funds in the process of innovation and also have a general additional incentive effect on corporate R&D investment (Li & Wan, 2019; Wang et al., 2017; Zhuang et al., 2018), thus promoting enterprise innovation and economic growth (Berube & Mohnen, 2009; Chen & Yang, 2016; Czarnitzki et al., 2011; Hitaj, 2013). The 'suppression theory' scholars believe that R&D subsidies may induce enterprises to over-reliance on the government, leading enterprises to spend a lot of resources to establish links with the government, weaken the company's own investment in innovation and research, and inhibit the innovation behaviour of enterprises to a certain extent (An et al., 2009; Boeing, 2016; Busom, 2000; Geng et al., 2011; Liao et al., 2013; Mayra & Sandonis, 2012; Yu et al., 2010). In addition, some scholars believe that there is an optimal subsidy interval between R&D subsidies and enterprise innovation. In the optimal subsidy interval, it will promote enterprise innovation, and will inhibit corporate innovation outside the optimal subsidy interval (Dominique & Bruno, 2003; Mao & Xu, 2015; Yu & Jiang, 2017; Zhang & Sun, 2018; Zhao & Wang, 2018). Other scholars (Tang & Luo, 2007) have found that R&D subsidies have no significant effects on the economic effects of enterprises, but only beneficial to Chinese listed companies in exerting their social effects.

Through analysis of relevant literatures, most studies focus on the impact of various factors at the enterprise level on innovation performance, and the focus on the regulatory role of executive background in R&D subsidies and corporate innovation is still insufficient. It is even rarer to distinguish between executive research backgrounds, academic backgrounds, and government backgrounds. The 'Executive Echelon Theory' (Hambrick & Mason, 1984) believes that executives, as core figures in business operations, have a significant impact on corporate innovation. However, the theory only focuses on the background of political connections of executives, and ignores the relationship between other heterogeneous backgrounds of executives and corporate innovation. At present, a small number of scholars have started to pay attention to the relationship between the heterogeneous background of executives and corporate innovation (Peng & Mao, 2017; Wei & Yi, 2017), but the executive background has become a research policy. An important issue that cannot be avoided in corporate relations.

In order to study how some of the background characteristics of corporate executives play a regulating role in government subsidy policies and corporate innovation,

what kind of economic and social effects can they bring to the company, and whether they can bring positive effects value? How to make government subsidy resources more effectively allocated and utilized? This article takes the heterogeneous background characteristics of executives as the starting point to explore the heterogeneous moderating role of executive backgrounds in government subsidies and corporate innovation. At the same time, the senior management background is divided into executive management political background, executive research and development (R&D) technology background and executive personal education background, and the empirical evidence is used to evaluate whether the government subsidy policy has effectively allocated subsidy resources.

2. Theory and hypotheses

2.1 R&D subsidies and corporate executive background

Government R&D subsidies tend to be distributed to companies with greater development potential, greater social benefits, and high quality and promising R&D projects. However, due to the information asymmetry between the government and enterprise, enterprises need to release some explicit signals to reduce the interference of 'information asymmetry'. The heterogeneous background characteristics of enterprise executives can be used as effective carriers of some dominant signals.

The political background of executives as a dominant signal carrier of the company will have a substantial impact on corporate innovation. The political background of executives can bring great convenience to companies – such as enjoying lower tax arrangements and financing costs and giving priority to government subsidies. In addition, the political background of executives can also break the restriction of 'information asymmetry', allowing enterprises to obtain the government's information on technological innovation policies first, thereby adjusting the orientation of corporate innovation and achieving better enterprise innovation.

The R&D technical background of corporate executives is likely to be another dominant signal carrier. The preferred R&D subsidy hypothesis shows that to achieve good political performance, government officials urgently need to obtain fast and efficient returns from enterprises. The government distributes R&D subsidies to R&D projects with good R&D capabilities, short R&D cycles, and low investment risks, and gives preferential support to enterprises. Executives with technical R&D background can more accurately grasp the direction and planning of enterprise technology development, reduce investment risks, improve innovation efficiency, and make enterprise innovation more efficient. R&D subsidies may tend to be allocated to companies with technical R&D background executives.

The academic background of corporate executives is likely to become another dominant signal carrier. Studies have shown that personal education has a positive impact on information processing capabilities. The degree of executive management reflects the knowledge accumulation and learning ability of executives to a certain extent, and affects their concept and foundation of employment, which in turn affect their behaviour and decision-making. Their professional background and skills are

conducive to finding good investment opportunities and making effective technological innovation decisions for the company.

We present the following three hypotheses about executive background and government R&D subsidies.

Hypothesis 1a: Compared to executives without a politically relevant background, the political context of executives can significantly promote firms to gain higher R&D subsidies.

Hypothesis 1b: Compared to executives without an R&D technical background, the R&D technical background of executives can significantly promote firms to gain higher R&D subsidies.

Hypothesis 1c: Compared to executives with low academic backgrounds, executives' high academic background can significantly promote firms to gain higher R&D subsidies.

2.2 R&D subsidies and corporate innovation

Unlike general market activities, high risk is a major feature of R&D activities, which restricts companies from engaging in R&D activities. In addition, R&D activities are external and public, which means that the company itself has insufficient motivation to conduct R&D activities. Under this circumstance, enterprises need government policy support. The government needs to bear the investment risks caused by innovation together with the enterprise to make up for the gap between the company's own innovation income and social benefits, thus motivating enterprises to increase R&D investment and improve their independent innovation ability.

Based on the previous analysis, we believe that China's R&D subsidy policy can significantly promote innovation in Chinese listed companies. On the one hand, R&D subsidies can solve the three characteristics of enterprise R&D activities: high risk, externality and publicity, thereby reducing R&D costs and corporate investment risks and improving corporate innovation performance. On the other hand, as an important external resource, R&D subsidies can transmit certain information to the market, drive and attract investment from all walks of life to listed companies, and increase the enthusiasm of enterprises for R&D innovation.

Therefore, we propose the following assumptions:

Hypothesis 2a: R&D subsidies can positively promote innovation activities of listed companies.

2.3 R&D subsidies, corporate executive background and listed company innovation

The political background of the company's executives can give enterprises preferential access to tax breaks, R&D subsidies, etc. However, the reality is that while enterprises enjoy additional benefits, they are also subject to government intervention. Enterprises need to undertake the responsibility of government to expand employment scale and maintain social stability and development. The aggravation of the

corporate policy burden will cause enterprises to reduce their corresponding innovative R&D investment or directly use R&D subsidies as their productive operating funds rather than investing in R&D innovation. That is, rent-seeking has a negative effect on corporate innovation.

Executives with a technical R&D background have high-level technical knowledge and professionalism, can accurately grasp the frontier technology context, reasonably evaluate the project's R&D risks, and formulate scientific and rational decision-making to lead the enterprise along the road of technological innovation. In addition, they will pay more attention to technical personnel and fully explore the potential of technical talent to promote corporate innovation. Furthermore, executives with a background in technology R&D will attach importance to the R&D activities of enterprises and will increase their proportion of R&D investment, which will directly affect technological innovation.

The higher the background of executive education, the greater their ability to accept new things and their ability to adapt to new environments. Their perspectives on problem-solving will be more accurate, they will have a deeper understanding of issues, and their ability to acquire and process information may be stronger. These capabilities of executives can improve the success rate of R&D projects, improve the decision-making quality of corporate executives and thus promote business innovation.

In summary, the following three hypotheses are proposed:

Hypothesis 3a: The background of executive political associations cannot significantly promote R&D subsidies for innovation of Chinese listed companies.

Hypothesis 3b: The background of executive technology R&D can significantly promote R&D subsidies for innovation of Chinese listed companies.

Hypothesis 3c: Executives' high-level academic background can significantly promote R&D subsidies for innovation of Chinese listed companies.

3. Model and variables

3.1. Executive background characteristics and R&D subsidies

To test whether the relevant background characteristics of corporate executives can affect the company's R&D subsidies, we draw on the research methods of predecessors (Peng & Mao, 2017). The function model established in this article is as follows:

$$Sub_{it} = \alpha + \beta_1 Pol_{it} + \beta_2 Tech_{it} + \beta_3 Degree_{it} + \beta_4 Pol_{it} \times Tech_{it} + \beta_5 Pol_{it} \times Degree_{it} \\ + \beta_6 Tech_{it} \times Degree_{it} + \beta_7 Pol_{it} \times Tech_{it} \times Degree_{it} + X' + Ind + Year + \varepsilon$$

(a)

Subscripts i and t represent China's listed companies and years respectively. X, Ind and $Year$ respectively represent the relevant control variables, industry dummy variables and year dummy variables in the model. α represents the intercept of the model, and ε represents the equation residual. Based on Hypothesis 1 presented above, we believe that the following conditions in equation (a) are true:

$$\beta_1 > 0, \beta_2 > 0 \ and \ \beta_3 > 0 \tag{a1}$$

3.2. Mediating effects of background characteristics of executives

The focus of this article is on whether executive background can promote the innovation of enterprises through the intermediary effect of government subsidies. Therefore, this article constructs three groups of models (b), as shown below, to test the mediation effect.

The first set of models explores the government background of executives:

$$\text{Model 1} \quad Patent = \alpha + \beta_1 Pol + X' + Ind + Year + \varepsilon \tag{b1}$$

$$\text{Model 2} \quad Sub = \alpha + \beta_1 Pol + X' + Ind + Year + \varepsilon \tag{b2}$$

$$\text{Model 3} \quad Patent = \alpha + \beta_4 Sub + X' + Ind + Year + \varepsilon \tag{b3}$$

$$\text{Model 4} \quad Patent = \alpha + \beta_1 Pol + \beta_4 Sub + X' + Ind + Year + \varepsilon \tag{b4}$$

The second set of models explores the technical background of executives:

$$\text{Model 1} \quad Patent = \alpha + \beta_2 Tech + X' + Ind + Year + \varepsilon \tag{b5}$$

$$\text{Model 2} \quad Sub = \alpha + \beta_2 Tech + X' + Ind + Year + \varepsilon \tag{b6}$$

$$\text{Model 3} \quad Patent = \alpha + \beta_4 Sub + X' + Ind + Year + \varepsilon \tag{b7}$$

$$\text{Model 4} \quad Patent = \alpha + \beta_2 Tech + \beta_4 Sub + X' + Ind + Year + \varepsilon \tag{b8}$$

The third set of models explores the educational background of executives:

$$\text{Model 1} \quad Patent = \alpha + \beta_3 Degree + X' + Ind + Year + \varepsilon \tag{b9}$$

$$\text{Model 2} \quad Sub = \alpha + \beta_3 Degree + X' + Ind + Year + \varepsilon \tag{b10}$$

$$\text{Model 3} \quad Patent = \alpha + \beta_4 Sub + X' + Ind + Year + \varepsilon \tag{b11}$$

$$\text{Model 4} \quad Patent = \alpha + \beta_3 Degree + \beta_4 Sub + X' + Ind + Year + \varepsilon \tag{b12}$$

Model 1 of the three sets of models is used to test the effect of three different background characteristics of executives on corporate innovation. Model 2 is used to test whether the three different background characteristics of executives have significant effects on government subsidies. Model 3 is used to test the significance of government subsidies to corporate innovation, and Model 4 is used to test the

significance of three heterogeneous background characteristics of executives on corporate innovation under the control of government subsidies of Chinese listed companies, that is, to test whether the government subsidy of the intermediary variable is significant.

We use Table 1 to illustrate the variables we chose.

4. Empirical analysis

4.1. Data and sample

The financial statement data required for this article is from the Wind financial database and the C.S.M.A.R. database and is reviewed, corrected and supplemented. The background information of the company's executives comes from the 'deep data' and the C.S.M.A.R. database in the Wind financial database, all of which are obtained by searching and reviewing the executives' resumés. In addition, the data is collated and supplemented by consulting other websites.[1]

We selected the listed companies of the A-shares and B-shares of the Shanghai Stock Exchange from 2008 to 2015 as samples, pre-processed the data[2], and finally obtained 730 companies with a total of 5,110 observations. The financial statement data required for this article comes from the Wind financial database and the Guotai'an database (C.S.M.A.R.). The company's executive background information comes from the 'In-depth Information' item in the Wind financial database and the Guotai'an database. In addition, we sorted and supplemented the data by manually searching the financial sections of Sina.com, Juchao.com, Baiteng.com and Fenghuang.com.

4.2. Empirical results of executive background characteristics and government R&D subsidies

We use two-stage least squares to estimate the model (a), and the regression results of model (a) are shown in Table 2 below.

Before the empirical analysis, we performed a multi-collinearity test on each variable in the model. The test results show that the V.I.F. values are all less than 10, so the multi-collinearity problem is absent in the regression analysis model constructed in this article.

As can be seen from Table 2, the coefficients of the government background and technical background items are significantly positive at the level of 5%. This result indicates that the background and technical background of corporate executives can promote the company to obtain more R&D subsidies, which is consistent with the hypotheses H1a and H1b. The academic background coefficient is significantly positive at the 10% significance level, indicating that the academic background of the executive can promote the company to obtain a higher R&D subsidy, and H1c can also be proved.

According to the nature of enterprise ownership, in state-owned companies, the coefficients of executive government background and technical R&D background items have not passed the significance test, while in non-state-owned companies, the three types of background characteristics of executives are significantly positive at the 5% level.

Table 1. Variable selection.

Variable	Dependent variable	Definition
1	R&D subsidy (*Sub*)	Ratio of R&D subsidy to business income
2	Number of patents applications (*Patent*)	The sum of the number of invention patents and the number of non-invention patent applications
	Independent variable	
1	Executive government background[1] (*Pol*)	If the corporate executive has a government background, assign it a value of 1. If the chairman or general manager does not have any political experience, assign it a value of 0.
2	Executive technical background (*Tech*)	If the executive's resume shows that the executive has work experience in a related technical position, or has a relevant technical professional learning experience, the company's executives can be considered to have a relevant technical background.
3	Executive education background (*Degree*)	The chairman or general manager of the company's management has a bachelor's degree or above
	Control variable	
1	Enterprise ownership form (*Soe*)	If the enterprise belongs to a state-owned enterprise, the value is 1; if the enterprise belongs to a private enterprise, the value is 0
2	R&D investment intensity (*RI*)	The ratio of R&D investment to total corporate assets
3	Business size[2] (*Size*)	We use the logarithmic value of the total assets of the enterprise to express the effect of controlling the scale characteristics of the enterprise itself on the innovation output of the enterprise. The size of the enterprise is determined according to official standards.
4	Assets and liabilities (*Lev*)	The ratio of total corporate debt to total assets
5	Capital intensity (*Klr*)	The ratio of the total value of fixed assets to the total number of employees in the enterprise
6	Tobin Q value (*Tobinq*)	The market value of the equity at the end of the period plus the sum of the book value of the liabilities, divided by the book value of the total assets at the end of the period
7	Cash flow (*CF*)	The natural logarithm of the net cash flow generated by the enterprise in its production and operation activities
8	Return on Assets (*Roa*)	The ratio of the total profit at the end of the enterprise to the total assets at the end of the period
9	Ownership concentration of enterprises (*Con*)	*Herfindahl* value of ownership of the top five shareholders of a business
10	Profitability (*profit*)	The ratio of total profit to total assets
11	Enterprise age (*Age*)	The logarithm of the effective establishment year of the enterprise during the sample observation period
12	Operating income growth rate (*Gro*)	The increase in annual operating income divided by the operating income of the previous year
13	Actual controller (*Ah*)	The proportion of shares held by the actual controller in the total share capital of a listed company
14	*Industry*	A dummy variable that is used to control industry differences.
15	*Year*	A dummy variable that is used to control annual differences

Note: [1]The government background refers to whether the chairman or general manager of the company is currently or has served as a government official of the central government or the provincial government, or whether they are also national, provincial or local people's congress representatives or CPPCC members.
[2]Notice of the Ministry of Industry and Information Technology, the National Bureau of Statistics, the National Development and Reform Commission, and the Ministry of Finance on Printing and Distributing the Standards for the standardisation of Small and Medium-sized Enterprises (Ministry of Industry and Information Technology [2011] No. 300).
Source: Wind financial database and the C.S.M.A.R. database.

In terms of firm size, the three types of background characteristics of executives are significantly positive in large-scale companies at least at a level of 5%, while in small-scale companies the coefficients do not pass significance tests. We believe that the possible reasons for such a result are as follows. Firstly, due to limited operating funds, it is difficult for small-scale companies to spend a lot of resources to keep in touch with the government. Secondly, as far as the technical background and

Table 2. The impact of executive heterogeneity background on R&D subsidy (Y = Sub).

Model variables	1 Total sample	2 State-owned enterprise	3 Non-state-owned enterprise	4 Large company	5 Small company
Pol	0.032** (2.34)	−0.002 (-0.32)	0.056** (2.39)	0.047*** (3.25)	0.021 (1.01)
Tech	0.228** (2.45)	0.059 (0.72)	0.231** (2.17)	0.314** (2.21)	0.076 (1.25)
Degree	0.008* (1.87)	0.098* (1.90)	0.007* (1.86)	0.042*** (3.20)	0.028 (1.03)
Pol*Tech	−0.045 (-1.28)	−0.022 (-0.54)	−0.027 (-0.79)	−0.045 (-1.21)	−0.023 (-0.32)
Pol*Degree	0.094 (0.67)	0.093 (1.41)	−0.132 (-1.15)	0.020 (1.09)	−0.007 (-0.77)
Tech*Degree	0.259 (1.16)	0.029 (1.01)	0.013 (0.07)	0.022 (0.18)	0.244 (1.10)
Pol*Tech*Degree	−0.003 (-0.67)	−0.005 (-1.55)	−0.001 (-0.44)	0.001 (0.59)	−0.004 (-1.34)

Note: ***, **, * indicate that the sample is significant at the 1%, 5%, and 10% levels, respectively, and the number in parentheses is the t-statistics.
Source: Wind financial database and the C.S.M.A.R. database.

academic background of corporate executives are concerned, the senior management of small enterprises is mostly senior employees who grow up and develop with the enterprise, making small enterprises less susceptible to the background characteristics of executives. Although the influence of the three types of heterogeneous background characteristics of executives on corporate innovation is not significantly supported, the positive coefficient still indicates that the educational background, government background and technical background of executives play a positive role in R&D subsidies. Detailed regression results can be found in Appendix A1.

4.3. Government R&D subsidies, background features of corporate executives and corporate innovation behaviour

The focus of this article is on whether executive background can promote the innovation of enterprises through the intermediary effect of government subsidies. The test results of model (b) are shown in Tables 3–5.

From the second column of Tables 3–5, the regression results show that the coefficients of Pol, Tech, and Degree all passed the significance test, meaning that the three heterogeneous background characteristics of executives can help companies to obtain higher government subsidies. H1a, H1b, and H1c are satisfied. From the regression results in the third column of Tables 3–5, the coefficient of Sub is significantly positive at the significance level of 1%, which means that the higher the government subsidy amount of the company, the more beneficial it is for Chinese listed companies' innovation. H2 is satisfied. From the regression results in the fourth column of Tables 3–5, we can see that the coefficients of Tech and Degree have passed the significance test and are positive values. The coefficient of Pol has not passed the significance test, which means that the government background of the executive can promote enterprises to obtain higher government subsidies, but is not conducive to corporate innovation. The technical background and personal education background of senior executives help Chinese listed companies to obtain higher government subsidies, thereby promoting corporate innovation, H3a, H3b and H3c are satisfied.

Further calculation of the estimated coefficients yields:

In the first set of models, the coefficients of model (b1) β_1 is 0.049, and t value is 0.34. The coefficients did not pass the significance test. So, we believe that there is a

Table 3. Regression results for the first set of models.

Dependent variable model	Patent 1	Sub 2	Patent 3	Patent 4
Sub			0.925*** (7.48)	0.907*** (6.94)
Pol	−0.049 (-0.34)	0.025*** (3.14)		−0.032 (-0.47)
Ind	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
N	5110	5110	5110	5110
Adjusted R^2	0.532	0.309	0.413	0.522
Mediating effect		0.023(0.025*0.907)		

Note: ***, **, * indicate that the sample is significant at the 1%, 5%, and 10% levels, respectively; the value in parentheses is the t-statistics. Controls represent the control variables in the model, limited to the length of the article, no results reported.
Source: Wind financial database and the C.S.M.A.R. database.

Table 4. Regression results for the second set of models.

Dependent variable model	Patent 1	Sub 2	Patent 3	Patent 4
Sub			0.925*** (7.48)	0.893*** (6.83)
Tech	0.654*** (5.36)	0.317** (2.52)		0.362* (1.79)
Ind	yes	yes	yes	yes
Year	yes	yes	yes	yes
Controls	yes	yes	yes	yes
N	5110	5110	5110	5110
Adjusted R^2	0.657	0.479	0.413	0.512
Mediating effect		0.283(0.317*0.893)		
		Mediating effect / total effect *100%=43.88%		
		Mediating effect / direct effect *100%=78.18%		

Note: ***, **, * indicate that the sample is significant at the 1%, 5%, and 10% levels, respectively; the value in parentheses is the t-statistics. Controls represent the control variables in the model, limited to the length of the article, no results reported.
Source: Wind financial database and the C.S.M.A.R. database.

Table 5. Regression results for the third set of models.

Dependent variable model	Patent 1	Sub 2	Patent 3	Patent 4
Sub			0.925*** (7.48)	0.922*** (7.14)
Degree	0483*** (3.99)	0.102* (1.94)		0.115* (1.82)
Ind	yes	yes	yes	yes
Year	yes	yes	yes	yes
Controls	yes	yes	yes	yes
N	5110	5110	5110	5110
Adjusted R^2	0.457	0.566	0.413	0.512
Mediating effect		Mediating effect =0.094(0.102*0.922)		
		Mediating effect / total effect *100%=44.98%		
		Mediating effect / direct effect *100%=81.74%		

Note: ***, **, * indicate that the sample is significant at the 1%, 5%, and 10% levels, respectively; the value in parentheses is the t-statistics. Controls represent the control variables in the model, limited to the length of the article, no results reported.
Source: Wind financial database and the C.S.M.A.R. database.

masking effect in the model. The coefficients of model (b2) β_1 and (b4) β_4 have passed the significance test. There are significant indirect effects in the model. The coefficient of model (b4) β_1 is not significant, indicating that the direct effect in the model is not significant, that is, only the mediation effect exists in the model and the mediation effect is 0.023.

In the second set of models, the coefficients of model (b5) β_2 have passed the significance test. So, we think there is a mediating effect in the model. The

coefficients of model (b6) β_2 and model (b8)β_4 have passed the significance test. There are significant indirect effects in the model. In the model (b8), β_2 is 0.362, and the value of t is 1.79, indicating that there is a significant direct effect in the model. The mediating effect is 0.283, and the direct effect is 0.362, so they have the same sign, indicating that the model belongs to a partial mediating effect model. Therefore, there is a direct effect between the technical background of executives and corporate innovation behaviour, and the impact of the technical background of executives on corporate innovation can also be achieved through government variable government subsidies of intermediate variables. The median effect value is 0.283, and the direct effect value is 0.362. The proportion of the intermediary effect to the total effect is 43.88%, and the proportion of the intermediary effect to the direct effect is 78.18%.

In the second set of models, the coefficients of model (b9) β_3 have passed the significance test. So, we think there is a mediating effect in the model. The coefficients of model (b10) β_3 and model (b12) β_4 have passed the significance test. There are significant indirect effects in the model. In the model (b12), β_3 is 0.115, and the value of t is 1.82, indicating that there is a significant direct effect in the model. The mediating effect is 0.094, and the direct effect is 0.115, so they have the same sign, indicating that the model belongs to a partial mediating effect model. Therefore, there is a direct effect between the personal education background of senior executives and corporate innovation behaviour, and the impact of the personal education background of senior executives on corporate innovation can also be achieved through the intermediary variable government subsidy. The mediating effect value with enterprise innovation is 0.094, the direct effect value is 0.115, the proportion of the mediating effect to the total effect is 44.98%, and the proportion of the mediating effect in the direct effect is 81.74%.

5. Conclusion and recommendation

5.1. Conclusion

This article takes the background characteristics of executive heterogeneity as the starting point and discusses the heterogeneity adjustment effect of executive background in R&D subsidies and corporate innovation behaviour. By constructing a theoretical analysis framework and using the public data of A-share and B-share listed companies in China's Shanghai Stock Exchange from 2008 to 2015 for empirical research, this article obtains the following main research conclusions.

First, there are still some preferences in the process of Chinese government's innovation subsidy allocation. The government background, technical background and high educational background of senior executives enable listed companies to get more R&D subsidies. In terms of company ownership and scale, the government background and technical background of executives did not show significance in state-owned companies, while in non-state-owned companies, these two variables were significant at 5% significance level. The possible reason is that it is much more difficult for non-state-owned companies to obtain R&D subsidies than state-owned companies. Therefore, compared with state-owned companies, the small changes in the government

background and technical background of non-state-owned companies will lead to large changes in the number of R&D subsidies. In short, the political connections of executives help non-state companies to acquire more R&D subsidies; in addition, companies with technical backgrounds are more likely to receive government R&D subsidies. The academic background item is significantly positive at the 1% level in large-scale enterprises, and the coefficient is positive in small-scale enterprises, but it has not passed the significance test. The reason may be that executives in small-scale enterprises are mostly senior employees who have grown up with the company, rather than directly hiring highly educated managers like large-scale enterprises, thus weakening the influence of individual qualifications in the small business executive team.

In the case that the three types of background characteristics of executives are conducive to the company's R&D subsidies, executives' government background has not significantly improved the innovative output of listed companies, while the technical background of the executives and the personal high academic background have significantly promoted the innovation of enterprises.

5.2. Recommendation

Based on the background characteristics of corporate executives and the special background of China's economic transition period, it is of great practical significance to explore the impact of R&D subsidies on the innovation of Chinese listed companies. This article puts forward some opinions on enterprise management.

5.2.1. Reduce political connections from the source and reduce the cost of corporate political connections

We suggest that companies should carefully examine the internal and external environment and their own conditions, and reasonably evaluate the benefits and costs of political connections, and then choose the most appropriate business and enterprise communication methods and strategies. Enterprises should minimise the government's intervention, maintain the relative independence of enterprises, reduce the relationship between enterprises and the government from the source and reduce the corresponding government linkage costs.

5.2.2. Improve the R&D institutions of enterprises and enhance the technical capabilities of senior executives

Based on the innovation subsidy selection hypothesis, government managers will 'optimise' R&D projects. Therefore, enterprises should increase their efforts to improve their own R&D institutions. Enterprise decision-makers should also participate in R&D work within the company to develop a more effective R&D plan and improve the success rate of projects, which not only can enhance their own innovation ability but also obtain government subsidies.

5.2.3. Strengthen the requirements for executive education

The research results show that executives with high academic background can not only directly promote the innovation behaviour of enterprises, but also help their

company to obtain more R&D subsidies, further reduce the risk of innovative R&D, and indirectly promote the company's innovation.

Notes

1. Websites include sina.com.cn, cninfo.com.cn, http://baiten.cnn and http://ifeng.com.
2. We performed the following pre-processing on the data. First, we eliminated companies with serious data shortages and incomplete executive information, as well as companies listed, delisted, suspended, ST, *ST, and PT during the sample observation period. Finally, the continuous variable is subjected to winsorize processing at the level of 1% to eliminate the interference of extreme outliers.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

An, T. L., Zhou, S. D., & Pi, J. C. (2009). The stimulating effects of R&D subsidies on independent innovation of chinese enterprises. *Economic Research Journal*, *2009*(10), 87–98 + 120.

Berube, C., & Mohnen, P. (2009). Are firms that receive R&D subsidies more innovative?. *Canadian Journal of Economics*, *42*(1), 206–225.

Boeing, P. (2016). The allocation and effectiveness of China's R&D subsidies-evidence from listed firms. *Research Policy*, *45*(9), 1774–1789.

Busom, I. (2000). An empirical evaluation of the effects of R&D subsidies. Economics of Innovation and New Technology, 9(2), 111–148.

Chen, L., & Yang, W. H. (2016). Do government subsidies stimulate enterprises' innovation? evidence from China's listed companies. *Studies in Science of Science*, *2016*(03), 433–442.

Czarnitzki, D., Hottenrott, H., & Thorwarth, S. (2011). Industrial research versus development investment: The implications of financial constraints. *Cambridge Journal of Economics*, *35*(3), 527–544. https://doi.org/10.1093/cje/beq038

Dominique, G., & Bruno, V. P. D. L. P. (2003). The impact of public R&D expenditure on business R&D. *Economics of Innovation and New Technology*, *12*(3), 225–243.

Geng, Q., Jiang, F. T., & Fu, T. (2011). Policy-related subsides, overcapacity and China's economic fluctuation – Empirical testing based on RBC model. *China Industrial Economics*, *2011*(05), 27–36.

Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, *9*(2), 193–206. https://doi.org/10.5465/amr.1984.4277628

Hitaj, C. (2013). Wind power development in the United States. *Journal of Environmental Economics and Management*, *65*(3), 394–410. https://doi.org/10.1016/j.jeem.2012.10.003

Li, J., & Wan, B. J. (2019). R&D subsidies and financing constraints: Based on the signaling theory. *Journal of Shanghai University of Finance and Economics*, *21*(06), 81–95 + 152.

Liao, X. L., Gu, W. Y., & Wang, L. Y. (2013). Research on the effects of public R&D subsidies, influencing factors and choices of objects. *China Industrial Economics*, *2013*(11), 148–160.

Mao, Q. L., & Xu, J. Y. (2015). The impact of government subsidies on new product innovation of enterprises – Based on the perspective of "moderate interval" of subsidy intensity. *China Industrial Economics*, *2015*(06), 94–107.

Mayra, R., & Sandonis, J. (2012). The effectiveness of R&D subsidies. *Economics of Innovation & New Technology*, *21*(8), 815–825.

Peng, H. X., & Mao, X. S. (2017). Government subsidies for innovation, company executives background and R&D investment-evidence from the high-tech industry. *Finance & Trade Economics*, *2017*(03), 147–161.

Tang, Q. Q., & Luo, D. L. (2007). An empirical study of R&D subsidy motivation and effects: Empirical evidence from Chinese listed companies. *Journal of Financial Research*, *2007*(06), 149–163.

Wang, G. G., Xie, F. J., & Jia, Y. (2017). Reconsider incentive mechanism of R&D subsidy policy: Based on exploration for external financing incentive mechanism. *China Industrial Economics*, *2017*(02), 60–78.

Wei, W., & Yi, Z. W. (2017). Heterogeneity, faultline in TMT and innovation strategy: Moderating effect of attention. *Technology Economics*, *2017*(01), 35–40.

Yu, M. G., Hui, Y. F., & Pan, H. B. (2010). Political connections, rent seeking, and the fiscal subsidy efficiency of local governments. *Economic Research Journal*, *2010*(03), 65–77.

Yu, W. T., & Jiang, F. X. (2017). A research on the leverage of public R&D investment on enterprise R&D investment. *Studies in Science of Science*, *2017*(01), 85–92.

Zhang, F., & Sun, W. (2018). The micro-mechanism of government R&D subsidy efficiency: Superposition of incentive effect and crowding-out effect – A theoretical interpretation and inspection. *Public Finance Research*, *2018*(04), 48–60.

Zhao, K., & Wang, H. Y. (2018). The two-way dynamic coupling and nonlinear relationship between R&D subsidy policy and innovation decision. *Economic Theory and Business Management*, *2018*(05), 43–56.

Zhuang, W. T., Li, F. F., & Li, A. L. (2018). Research on the impact of government subsidies on enterprise performance. *Communication of Finance and Accounting*, *2018*(30), 53–57.

Appendix

Table A1. The impact of executive heterogeneity background on Sub (Y = Sub).

Model Variables	1 Total sample	2 State-owned enterprise	3 Non-state-owned enterprise	4 Large company	5 Small company
Pol	0.032** (2.34)	−0.002 (-0.32)	0.056** (2.39)	0.047*** (3.25)	0.021 (1.01)
Tech	0.228** (2.45)	0.059 (0.72)	0.231** (2.17)	0.314** (2.21)	0.076 (1.25)
Degree	0.008* (1.87)	0.098* (1.90)	0.007* (1.86)	0.042*** (3.20)	0.028 (1.03)
Pol*Tech	−0.045 (-1.28)	−0.022 (-0.54)	−0.027 (-0.79)	−0.045 (-1.21)	−0.023 (-0.32)
Pol*Degree	0.094 (0.67)	0.093 (1.41)	−0.132 (-1.15)	0.020 (1.09)	−0.007 (-0.77)
Tech*Degree	0.259 (1.16)	0.029 (1.01)	0.013 (0.07)	0.022 (0.18)	0.244 (1.10)
Pol*Tech* Degree	−0.003 (-0.67)	−0.005 (-1.55)	−0.001 (-0.44)	0.001 (0.59)	−0.004 (-1.34)
RI	0.203*** (3.36)	0.270*** (2.62)	0.126*** (3.32)	0.250*** (3.32)	0.228*** (2.97)
Soe	0.024 (0.62)			−0.030 (-0.57)	0.058 (1.12)
Size	−0.028 (-1.21)	−0.051* (-1.84)	−0.005 (-0.47)	−0.052 (-1.08)	−0.025 (-1.11)
Lev	−0.005*** (-5.98)	−0.006*** (-3.44)	−0.006*** (-4.53)	−0.007*** (-5.45)	−0.004** (-2.53)
Klr	−0.204* (-1.76)	−0.310** (-2.16)	−0.162 (-1.06)	−0.422*** (-2.88)	−0.057 (-0.37)
Tobinq	0.087*** (6.36)	0.076*** (6.94)	0.090*** (6.56)	0.002*** (4.70)	0.003*** (3.42)
Lncf	−0.038** (-2.40)	−0.022 (-1.29)	−0.026** (-2.22)	−0.004 (-0.26)	−0.027* (-1.82)
Roa	−0.012** (-2.05)	−0.015** (-2.48)	−0.002 (-0.56)	−0.007* (-1.71)	−0.004 (-0.76)
Gro	−0.001 (-0.16)	−0.012** (-2.29)	0.011 (1.32)	−0.008 (-1.36)	0.003 (0.52)
Ah	0.063* (1.78)	0.132* (1.82)	0.008* (1.69)	0.150** (2.17)	0.047* (1.93)
Ind	control	control	control	control	control
Year	control	control	control	control	control
Cons	1.352*** (7.31)	1.468*** (6.02)	1.213*** (3.49)	1.768*** (4.88)	1.651*** (3.21)
N	5110	1974	3136	1806	3304
Adjusted R^2	0.231	0.155	0.148	0.128	0.105

Notes: ***, **, * indicate that the sample is significant at the 1%, 5%, and 10% levels, respectively; the value in parentheses is the t-statistics.