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Interplay of Government Support and Foreign Investment in Enhancing R&D in China's Strategic Sectors

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Abstract: This investigation explores the intricate relationship between government support, foreign investment, and research and development (R&D) commitment in China's strategic sectors, with a focus on the crucial role of government assistance in spurring innovation in small-scale enterprises. Utilizing advanced deep learning and data mining techniques, the impact of government subsidies and tax incentives on R&D dedication in burgeoning strategic firms is meticulously analyzed, particularly in the context of varying levels of external financing. The findings reveal a significant, multifaceted influence of government financial aid and foreign capital on R&D endeavors. A pronounced, positive correlation between government financial backing and R&D activities emerges, with the magnitude of this relationship being substantially modulated by the degree of external investment. This underscores the importance of strategic financial orchestration in nurturing research and innovation within pivotal sectors. Insights gleaned from this study are of paramount importance for policy formulators and business leaders, offering a refined comprehension of the synergistic interplay between government incentives, foreign investment, and R&D commitment. These findings are pivotal for promoting economic growth and technological progress in China's key industries.

Keywords: Deep learning (DL); Diverse business ecosystems; External funding; Government financial support; R&D innovation

1. Introduction

The economic growth of China heavily relies on its strategically significant emerging industries, which are propelled by the country's rapid progress in new technology, business methods, and corporate ingenuity. The creative capacity of these enterprises is crucial for promoting exceptional economic growth. This study examines the impact of government funding on micro-enterprises in China's strategically significant emerging industries that prioritize innovative research and development (Seow et al., 2021).

The study uses deep learning data mining techniques to evaluate the influence of government financial support on external financing and R&D innovation dedication to explore this link. Based on well-established theories, hypotheses are formed, and an empirical model is created to examine how government financial aid affects firm finance and R&D commitment (Song & Zhao, 2022). Tests for multicollinearity and robustness validate the suggested hypothesis' validity. Regression analysis and descriptive statistics are used in the study, which focuses specifically on the strategic new enterprise sub-industry. The government's implementation of support measures, such as tax incentives and financial help, and their effect on strategic emerging firms scrutinizes the role it plays in promoting innovation and R&D dedication (Chen, 2021). The study also investigates the differences in these linkages among businesses with different amounts of outside funding. The results show that tax breaks and financial subsidies from the government have a beneficial effect on strategic developing companies' commitment to creative R&D (Jin et al., 2018). Additionally, the study finds that the relationship between government assistance and R&D dedication is highly influenced by the amount of external finance, highlighting the significance of taking financing levels into account when developing successful policies to foster innovation in these industries. This study emphasizes how important government funding is for encouraging innovation and R&D commitment in China's strategically important developing industries, which in turn promotes high-quality economic growth (Zhang & Zhang, 2022). Policymakers and industry stakeholders looking to promote innovation and propel economic development in this critical sector can learn a lot from the outcomes. The key to enhancing enterprise capabilities is a commitment to creativity. However, it has funding limitations, uncertainties, and information gaps. Government subsidies can strengthen internal resources or outside funding while mitigating external difficulties (Audretsch & Belitski, 2020; Sun et al., 2023; Sung, 2019; Wang & Sawur, 2022). Although strategic emerging industries have promise, they also face obstacles, which is why different government support programs are designed to encourage innovation and maximize resource use. Urgent research is needed to determine how government support affects the innovativeness of emerging businesses. Many studies look at this relationship, but not many address it from the standpoint of enterprise heterogeneity in various industries. This paper evaluates the impact of government funding support on innovation and R&D commitment in startups using deep learning (DL) techniques (Sung, 2019). The conclusions seek to improve coordination between the government and business in China and to direct fiscal policy.

2. Background

2.1 Relevant Theoretical Work

2.1.1 Variability in enterprise

Businesses differentiate themselves from one another through their internal core knowledge and unique capabilities, which are valuable, difficult for competitors to imitate, and non-replicable. Their profitability and competitive advantage stem from their enterprise heterogeneity, which is fueled by factors like productivity, enterprise size, ownership, and industry (Jia et al., 2021; Li et al., 2023; Rege & Lee, 2022; Zaman & Zaccour, 2021).

2.1.2 Theories concerning financial framework

Both external and internal funding are included in enterprise financing structures. Relevant theories cover topics like signaling, financing priority, and information asymmetry. Whereas external financing includes both direct and indirect means, internal financing is further divided into self-generated funds and retained earnings (Alom et al., 2019). See Figure 1 for further information.

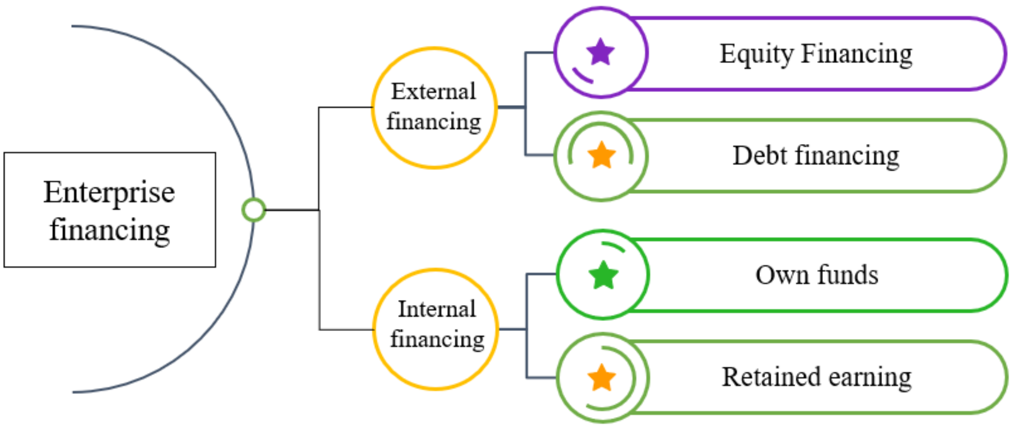


Figure 1. Enterprise financing structure

The external enterprise financing shown in Figure 1 includes debt financing, which includes private, bond, and bank loans, and equity financing, which includes venture capital and stock financing. Both self-generated money and retained earnings are used for internal financing.

2.1.3 Financing from the government

One essential tool for the sensible distribution of resources is financial assistance from the government. It is a useful instrument for boosting business competitiveness, encouraging innovation and growth, and funding initiatives that raise public welfare (Daspit et al., 2021; Hammad et al., 2020). This assistance promotes local economic standards, stabilizes faltering businesses, and guarantees steady government fiscal revenues (Cust et al., 2019). In addition, government funding guides money into creative business projects by sending signals, making commitments, and changing the way outside funding works (Alam et al., 2019). Figure 2 shows how financial assistance from the government affects enterprise creativity.

In Figure 2, financial support from the government is clearly visible as direct incentive policies that influence the commitment of enterprises to research and development. Additionally, it acts as an indirect incentive policy by influencing the enterprise financing structure through the signaling effect and the involvement of external financing entities. By providing capital, these financing organizations change the financing structure and produce a win-win scenario that benefits all parties involved.

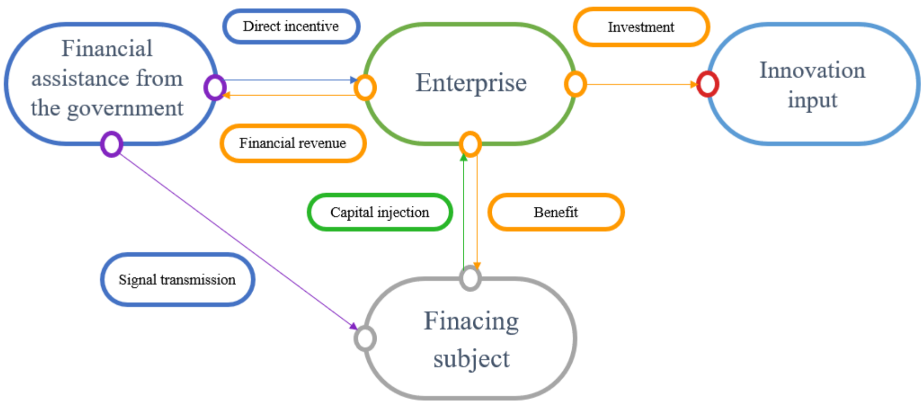


Figure 2. Financial support system provided by the government to encourage greater enterprise creativity dedication

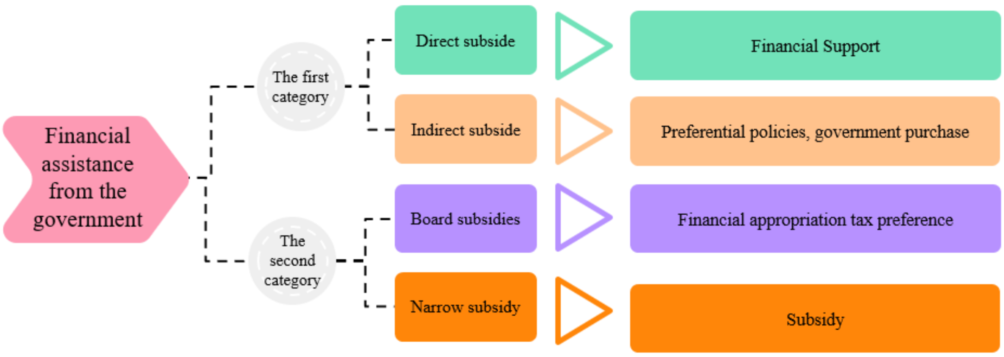


Figure 3. Government financial support classification

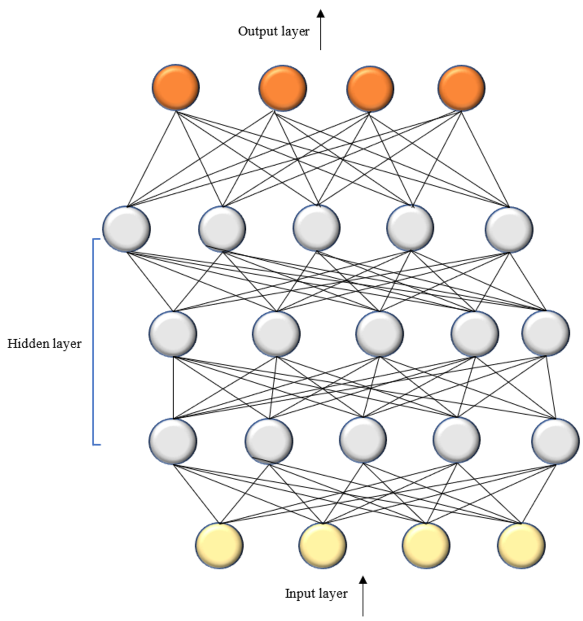


Figure 4. The basic structure of deep learning

As shown in Figure 3, the categorization of government financial assistance takes into account both broad and narrow as well as direct and indirect relationships (Ahn et al., 2020; Lin & Luan, 2020; Xie et al., 2020).

With reference to Figure 3, direct subsidies pertain to the process by which the government directly finances businesses through funding. Conversely, indirect subsidies come in different forms, such as government procurement and preferential policies. Contributions, in their wider sense, include providing favorable policies that assist businesses, such as tax breaks and financial subsidies. Narrow subsidies, on the other hand, are equivalent to direct subsidies, which are capital subsidies in which the government gives businesses direct capital infusions (Demirel & Danisman, 2019; Fu et al., 2020; Zhao et al., 2022).

2.2 Deep Learning Model

2.2.1 Theory of deep learning

A class of methods used to train deep neural networks (NN) is called deep learning, also known as deep structured learning. The input layer, hidden layers, and output layer make up the DL framework. Deep networks in deep learning can extract complex features from unprocessed data. Figure 4 shows the specific model architecture. Many approaches to solving such challenges have been proposed by the studies (Abid & Saqlain, 2023; Haq & Saqlain, 2023a; Haq & Saqlain, 2023b; Saqlain, 2023; Saqlain & Xin, 2020; Saqlain et al., 2020).

As seen in Figure 4, the basic model is made up of an output layer, several hidden layers, and an input layer. The underlying data feature distribution is revealed through the progressive extraction of features from the input layer to the top layer in deep learning. The input and output layers are directly connected by means of the hidden layers (Li et al., 2020). Unsupervised training is applied in this process, building layers upon layers until the top is reached.

2.2.2 Assessment of models based on deep learning

In the DL-NN model, the feature sample data *X* trained by computational thinking, the parameters $V^{[1]T}$, and $B^{[1]}$to the first hidden layer are input. Then, the pre-activation output $Z^{[1]}$ can be obtained.

$$Z^{[1]} = V^{[1]T}X + B^{[1]} \tag{1}$$

Then, the hidden layer $A^{[l]}$ is obtained. Next, the parameters $V^{[2]}$,$B^{[2]}$ and $A^{[l]}$ are input into the second hidden layer. In addition, $Z^{[2]}$ and $A^{[2]}$ are acquired. The calculation is repeated according to this rule, and this propagation method is called forward propagation (Alam et al., 2019; Cust et al., 2019). The calculation process is as follows:

$$A^{[l]} = G\left(Z^{[l]}\right) \tag{2}$$

$$Z^{[2]} = w^{[2]T}A^{[l]} + B^{[2]} \tag{3}$$

$$A^{[2]} = G\left(Z^{[2]}\right) \tag{4}$$

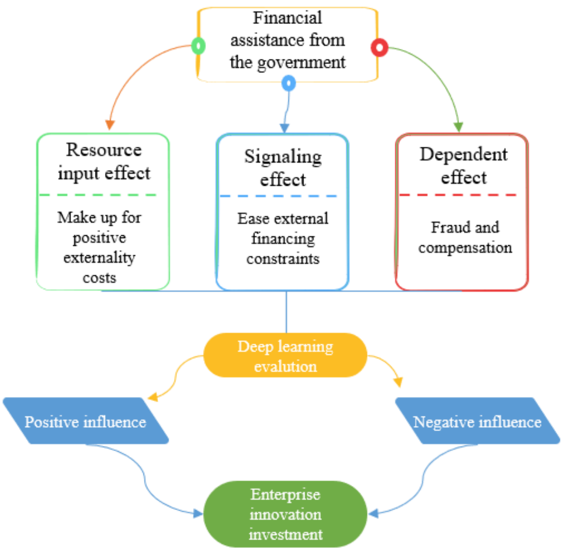


Figure 5. The impact of government financial assistance on innovative R&D dedication and enterprise external financing

2.3 Government Financial Aid's Effect on External Enterprise Financing and How It Affects Innovation and R&D Dedication Mechanisms

This study examines the mechanisms by which government financial support affects enterprise external financing, creativity, and R&D dedication. It does this by drawing on relevant literature, the theory put forth in this paper, and research findings. The enterprise heterogeneity framework serves as the foundation for this investigation (Bianchi et al., 2019). The procedural mechanism is shown in Figure 5.

Figure 5 reveals three primary impacts of government financial support on creative contribution from enterprises: reliance, resource input, and signal transmission. Government support compensates for beneficial external costs by providing resources, hence increasing company motivation for innovation and research and development. The signaling effect reduces external financial limitations, hence creating financing opportunities (Liu & White, 2001). An extensive analysis and assessment demonstrate that government support for creative research and development has a positive impact. Conversely, an excessive amount of financial assistance might result in certain enterprises excessively depending on government funding, potentially resulting in fraudulent claims for subsidies. To access government financial aid, certain enterprises may sacrifice the quality of their originality and engage in low-tech inventive endeavors, resulting in a negative impact on overall company creativity (Song & Zhao, 2022).

2.4 Research Design

2.4.1 Research hypotheses

The nature of an organization's R&D efforts defines its commitment, which can involve significant risks and expenses. An enterprise that depends entirely on its own resources may not have an equitable distribution of risks and rewards. Therefore, government funding is necessary for businesses to maintain their commitment to R&D, create social benefits, and protect their rights and interests while pursuing cutting-edge R&D. Most strategically oriented emerging businesses usually seek outside funding.

Findings from prior studies, mechanism analysis, and theoretical research all support the study's hypotheses (Zhao et al., 2022).

- H1: Innovative R&D dedication in strategic emerging enterprises is enhanced by government support.
- H1a: Government funding encourages creative R&D commitments from strategically positioned emerging businesses.
- H1b: Tax incentives also support strategic emerging enterprises' commitment to creative R&D.
- H2: The degree of funding considerably reduces the impact of government funding on the inventiveness and commitment to research and development of strategically important emerging businesses.

2.4.2 Outlining important variables

Financial subsidies and tax incentives are considered explanatory variables in this context, whereas R&D dedication is the explained variable. Financing levels, enterprise profitability, enterprise size, solvency, enterprise age, and the major shareholders' shareholding ratio are examples of control variables. Table 1 provides specifics about each of the symbols (Fu et al., 2020).

Table1. Key elements and symbols

	Variable Name	Variable Symbol
Explained variable	R&D dedication	RD
Explanatory variable	Financial subsidies	Sub
	Tax incentives	Tax
Control variables	Financing level	Debt
	Enterprise profitability	Roe
	Enterprise size	Size
	Long-term solvency	Lev
	Short-term solvency	Lipi
	Enterprise age	Age
	The shareholding ratio of major shareholders	Top

2.4.3 Choosing data sources and samples

The first step in the study's sample selection process is to define sub-industry categories using data from WIND and the State Council's strategic emerging industries report. The WIND database is the main source of the sample data, with additional information sourced from the China Stock Market & Accounting Research database. When certain businesses lack certain variables, the required information is obtained by cross-referencing their annual financial reports. The dataset includes 300 data points from 2018 to 2021, covering 100 strategically important emerging companies that are listed on the Shenzhen and Shanghai stock exchanges. Four industries comprise these businesses: high-end intelligent manufacturing (D), new biotechnology (C), new energy (B), and new generation information technology (A) (Jiang et al., 2020).

2.5 Empirical Research

The model treats R&D creativity dedication (RD) as the dependent variable and government financial assistance as the independent variable when analyzing the effect of financial aid on enterprise R&D creativity dedication.

$$RD = \gamma Support + Control + \sigma \tag{5}$$

Control in Eq. (5) refers to additional pertinent variables, while 'Support' denotes government financial aid. 'γ' is the regression coefficient, and 'σ' stands for random error (Haq & Saqlain, 2023a).

Government financial subsidies and tax incentives are the two categories into which this study divides government financial support for analysis. Control variables, including age, solvency, profitability, equity concentration, and company size, are also included. While the second model investigates the effect of tax incentives on innovative R&D dedication, the first model evaluates the effect of government financial support on the inventiveness and R&D dedication of strategic emerging enterprises (Saqlain, 2023).

$$\begin{gathered} RD_i = \alpha + \gamma_1 Sub_i + \gamma_2\, Lev_i + \gamma_3 Age_i + \gamma_4\, Size_{\,i} + \gamma_5\, Top_{\,i} \\ +\gamma_6\, Lipi\ + \gamma_7\, Roe_i + \Sigma_{year}\ + \Sigma_{industry}\ + \mu_i \end{gathered} \tag{6}$$

$$\begin{gathered} RD_i = \alpha + \gamma_1 Tax_i + \gamma_2\, Lev_i + \gamma_3 Age_i + \gamma_4\, Size_{\,i} + \gamma_5\, Top_{\,i} \\ +\gamma_6\, Lipi\ + \gamma_7\, Roe_i\ + \Sigma_{year}\ + \Sigma_{industry}\ + \mu_i \end{gathered} \tag{7}$$

The third model incorporates financial assistance from the government and tax incentives into the model, as shown in Eq. (8).

$$\begin{gathered} RD_i = \alpha + \gamma_1 Sub_i + \gamma_2 Tax_i + \gamma_3 Age_i + \gamma_4\, Size_{\,i} + \gamma_5\, Top_{\,i} \\ +\gamma_6\, Lipi\ + \gamma_7\, Roe_i + \gamma_8\, Lev_i + \Sigma_{year}\ + \Sigma_{industry}\ + \mu_i \end{gathered} \tag{8}$$

The financing level variable is incorporated into the model to evaluate the impact of government financial assistance on the innovative R&D commitment of strategic emerging enterprises across a range of financing levels. To examine the coefficient of this term, it is necessary to consider the presence of a multiplication term involving the independent variable. The effects of tax breaks and government funding assistance on business innovation and R&D commitment are examined in the fourth and fifth models.

$$\begin{gathered} RD_i = \alpha + \gamma_1 Sub_i + \gamma_2 Sub_i * Debt_i + \gamma_3 Debt_i + \gamma_4\, Size_{\,i} + \gamma_5\, Top_{\,i} \\ +\gamma_6\, Lipi\ + \gamma_7\, Roe_i + \gamma_8\, Lev_i + \gamma_9 Age_i + \Sigma_{year}\ + \Sigma_{industry}\ + \mu_i \end{gathered} \tag{9}$$

$$\begin{gathered} RD_i = \alpha + \gamma_1 Tax_i + \gamma_2 Tax_i * Debt_i + \gamma_3 Debt_i + \gamma_4\, Size_{\,i} + \gamma_5\, Top_{\,i} \\ +\gamma_6\, Lipi\ + \gamma_7\, Roe_i + \gamma_8\, Lev_i + \gamma_9 Age_i + \Sigma_{year}\ + \Sigma_{industry}\ + \mu_i \end{gathered} \tag{10}$$

3. Result Calculations

3.1 Descriptive Variable Statistics

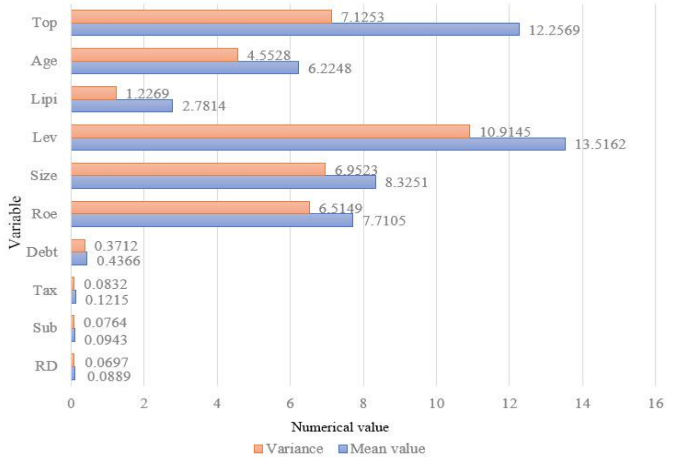
3.1.1 Key model variable statistics

The main variables in the model were the subject of a descriptive statistical analysis, the results of which are shown in Figure 6.

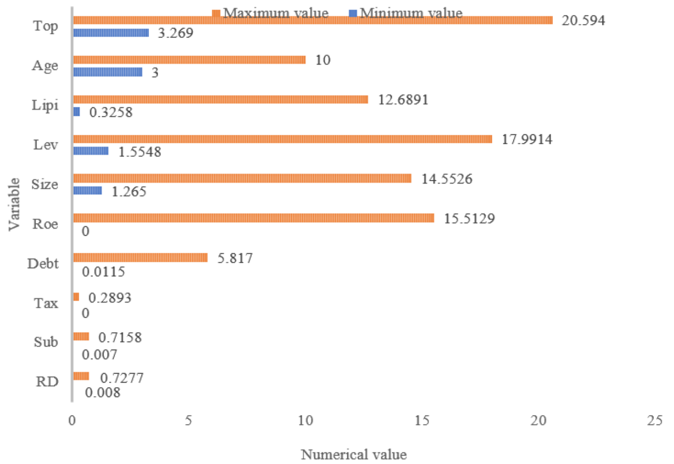
Figure 6 sheds light on the intensity and dedication of R&D. Strategic emerging enterprises have a high R&D intensity, as indicated by their mean R&D value of 0.0889. Nonetheless, these businesses' levels of R&D intensity differ significantly from one another. With a minimum of 0.007 and a maximum of 0.7158, government financial assistance varies greatly, reflecting notable individual differences in support for these businesses. As a result, the effects of government funding assistance on business creativity are diverse. With an average enterprise size of 8.3251, the scale of the business is moderate. The majority of businesses are still in their infancy but have enormous growth potential (Boeing et al., 2022). With considerable variation, the average profitability is 7.7105 and frequently falls below the 15% mark, which is consistent with the lengthy payback period of strategic emerging enterprises. The average long-term solvency is 13.5162, which shows a respectable capacity to use outside funding.

See Figure 7 for descriptive statistics based on enterprise heterogeneity for variables across various industries.

Different industries call for different kinds of government subsidies (Pandian, 2021). The average R&D intensity varies by industry, as shown in Figure 7. The industry for new-generation information technology stands out as having the highest average R&D intensity due to its intense R&D efforts. Additionally, this industry's enterprises display the widest range of R&D intensity. With differing degrees of commitment to R&D, the new biotechnology, luxury intelligent manufacturing, and new energy sectors come next (Zlotenko et al., 2019). The information technology sector of the new generation has the highest averages for tax incentives and government financial assistance. This implies that the overall R&D dedication intensity of enterprises and government support, as well as favorable tax policies within each industry, are positively correlated. The R&D intensity of the participating companies increased with increased government support, supporting hypothesis H1.

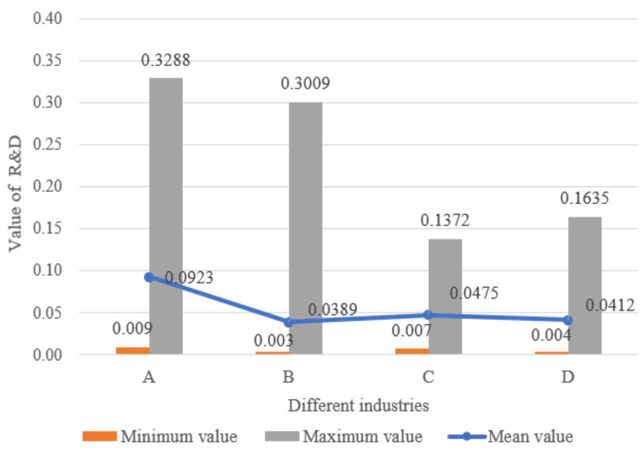


(a) Mean and variance statistics

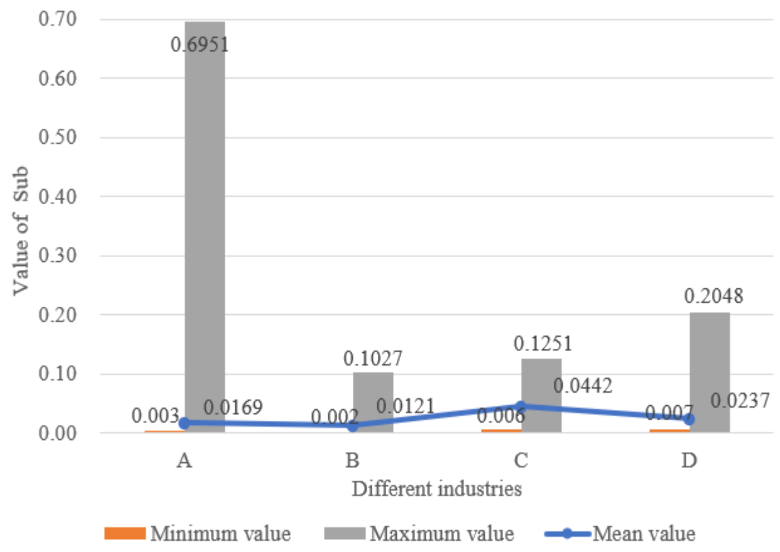


(b) Minimum and maximum statistics

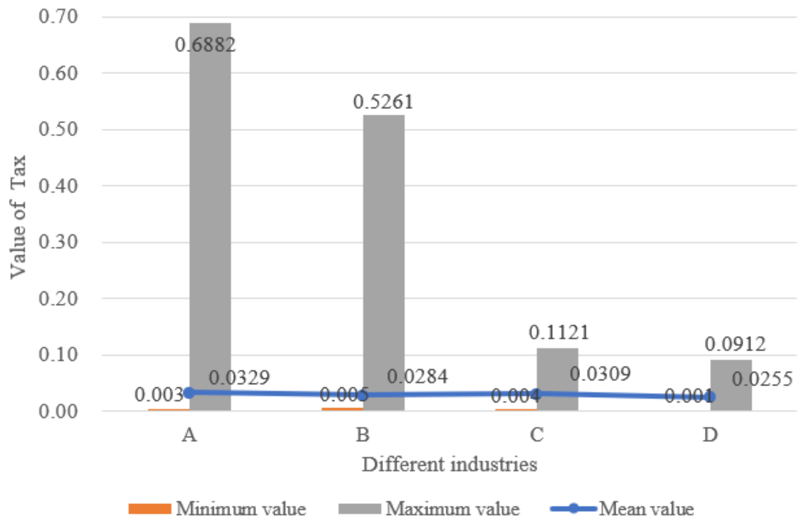
Figure 6. Variable description statistics



(a) Statistics on R&D intensity



(b) Government financial assistance



(c) Tax incentives

Figure 7. Descriptive statistics by industry

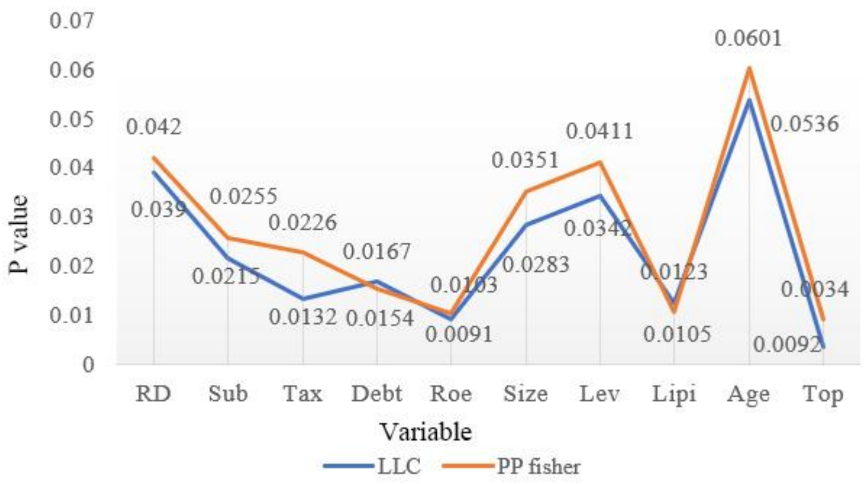


Figure 8. Stationarity test of the main variable

3.2 Testing for Panel Stability

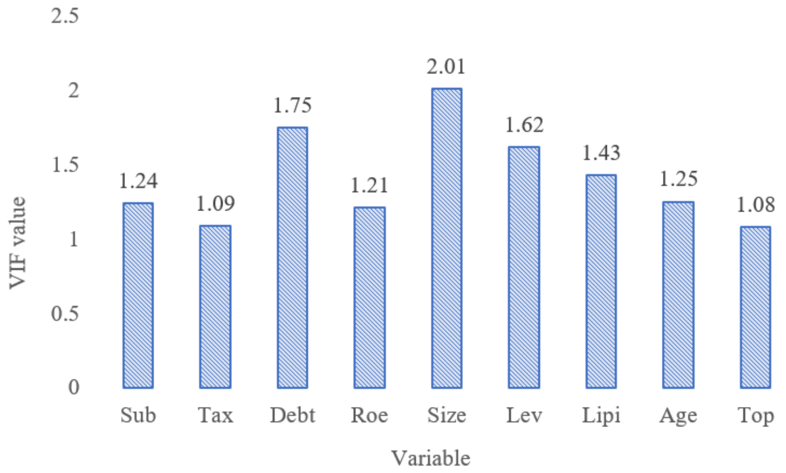
It is crucial to prevent spurious regression before doing regression analysis. The presence of spurious trends in non-stationary panel data can taint empirical findings. As a result, data stationarity must be evaluated. Each variable is tested using the Levin-Lin-Chu (LLC) test and the Phillips-Perron Fisher (PP Fisher) test. Either a homogeneous or heterogeneous unit root is assumed for the purposes of these tests. Whereas the PP Fisher test looks at inhomogeneous unit roots, the LLC test is intended to test homogeneous unit roots. Figure 8 presents the outcomes of these tests.

The variable P-values from both test methods are below 5%, significantly different from one, and nearly zero in the stationarity test. In these situations, the panel data is stationary and does not show a unit root, rejecting the null hypothesis that a unit root is present. This suggests that the data can be analyzed using a regression model.

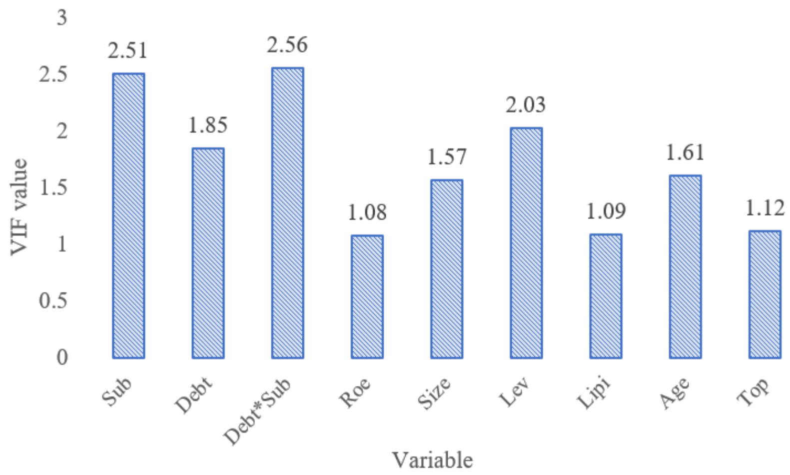
3.3 Evaluation of Multicollinearity

Accurate model parameter estimation can be hampered by inadequate data collection and interdependencies among explanatory variables. The occurrence of multicollinearity may impact the predictive power of the model. Each model variable is evaluated and error-corrected using the Variance Inflation Factor (VIF). Figure 9 presents the findings.

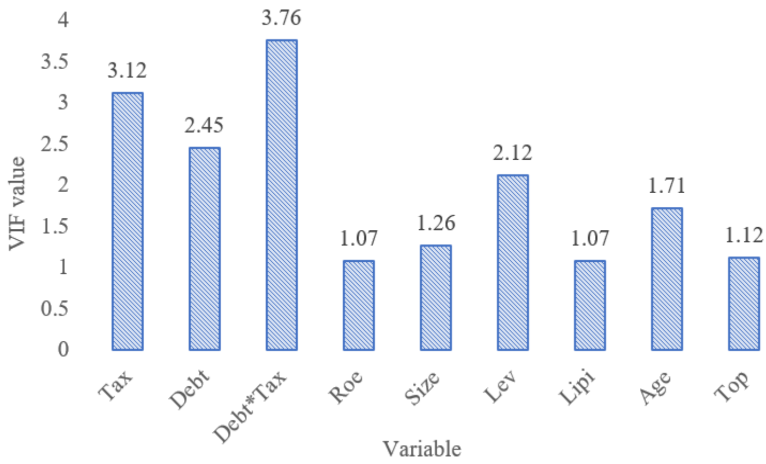
The magnitude of the VIF value indicates how severe multicollinearity is. The VIF values for the third model, the fourth model, and the fifth model are shown in subfigures (a), (b), and (c) of Figure 9. Among the explanatory variables, like Sub, Tax, and other control variables, the highest weighted correlation coefficient factor is 3.76. The VIF values for the various variables are quite low, significantly less than the ten-multicollinearity threshold. Therefore, there is no proof that the variables are multicollinear, and the model does not need to be changed. The model design is still appropriate.



(a) The third model test



(b) The fourth model test



(c) The fifth model test

Figure 9. Multicollinearity test

3.4 An Examination of the Effects of Government Funding Assistance on Innovation and R&D Commitment in Strategically Emerging Businesses

An examination of four industries (A, B, C, and D) reveals how government financial assistance affects enterprises' creativity and commitment to research and development. Enterprise Heterogeneity as a Basis.

Table 2. Government financial assistance's effect on business innovation and R&D investing

Variable	A	B	C	D
Sub	0.9638***	0.8239***	0.1768***	0.3756***
Tax	0.9328***	0.4269**	0.1132**	0.1598***
Lev	-0.002***	-0.002***	-0.004**	-0.006
Roe	-0.005	-0.006	-0.002	-0.006
Size	0.0031	0.0029	-0.0016	0.008
Top	-0.009***	-0.009***	-0.001	-0.001
Age	0.003	0.004	-0.006	-0.007***

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively.

Table 2 indicates that for every industry, the coefficients of Sub (financial subsidies) and Tax (tax incentives) are notably positive. Financial subsidies specifically increase the inventiveness and R&D commitment of emerging companies in the IT sector; for every unit of financial support, R&D commitment increases by 0.9638 units. This suggests that government funding, to varied degrees depending on the industry, fosters enterprise innovation and commitment to research and development. Enterprise R&D is positively influenced by tax incentives, which also have a notable and positive impact on enterprise creativity. H1a and H1b are supported by these findings.

3.5 Examining the Effects of Different Financing Levels on Government Financial Assistance on Innovation and R&D Devotion

Figure 10 presents the results of an examination of the effect of government financial assistance on the inventiveness and commitment to research and development of businesses with different financing levels.

Figure 10 presents the findings from the fourth model, which comprises the interaction term 'Debt Sub' and the variable 'Debt'. The coefficient of 0.9579 indicates a strong positive correlation between 'Sub' and R&D. The coefficient of 'Debt Sub' is -0.8572, indicating that the relationship between enterprise R&D dedication and government financial assistance differs among strategic emerging enterprises with varying financing levels (Saqlain et al., 2023). The government's financial subsidies' incentive effect on R&D dedication is lessened by higher financing levels. 'Sub' and 'RD' continue to have a strong positive correlation even when the fourth and fifth regression models are combined. The 'Debt*Sub' interaction term has a coefficient of -1.3692, which suggests that the financing levels have a negative impact on the impact of government financial assistance on the commitment to innovative R&D within strategic emerging enterprises. These results validate H2. To foster innovation in R&D, businesses should recognize the vital role that creativity plays, strengthen government support, increase information disclosure, and draw in outside funding.

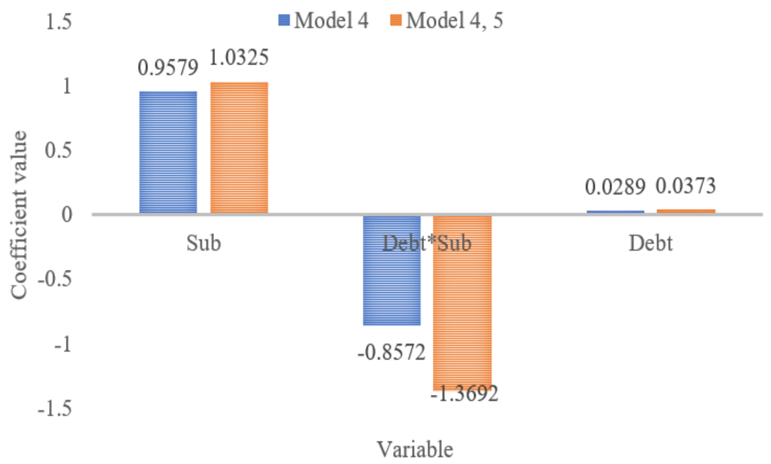


Figure 10. The influence of financial assistance from the government on creativity and R&D dedication of enterprises with different financing levels

4. Conclusion

Organizations are required to demonstrate heightened innovation in response to the rapid progress of technology and business. The Chinese government use financial assistance to foster autonomous research and development, stimulate enterprise innovation, and facilitate the sustainable expansion of developing sectors. This work integrates the concept of company heterogeneity and synthesizes theories related to financing and government support. The document presents a deep learning evaluation framework and elucidates the impact of government aid on external financing and innovative research and development initiatives. The empirical model, supported by analysis, confirms that government investment has a positive impact on the dedication of strategic developing enterprises to research and development. However, the level of foreign finance has a negative moderating effect on this relationship. Further investigation is necessary to examine the supplementary impacts of government financial aid.

Data Availability

The experimental data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The authors declare no conflicts of interest regarding this work.

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