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The Impact of Government Subsidies and R&D Investment on the Operating Performance of New Energy Enterprises in China

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

This paper selects the data of listed companies of new energy enterprises in China from 2017 to 2021 for empirical analysis to explore the impact of government subsidies and R&D (research and development) investment on operating performance using the panel data fixed effects model. The results show that in new energy enterprises, R&D investment and government subsidies are positively correlated with operating performance. When R&D investment and government subsidies exist at the same time, the interaction effect triggered by the two will play a positive moderating effect on business performance, but the promotion effect of both on business performance is weakened; at this time, the government subsidies have a better promotion effect on business performance. Based on the above findings, this paper puts forward the following suggestions: the government and related departments should optimize the subsidy mode of new energy enterprises, reduce direct subsidies, and adopt indirect subsidy policies such as tax incentives, to avoid excessive dependence on direct subsidies.

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Keywords: New energy enterprises; government subsidies; R&D investment; business performance.

1. INTRODUCTION

To promote the development of new energy enterprises, and encourage enterprises to increase R&D investment, China has taken a series of strong measures, the implementation of a government subsidy policy, in just a few years, China's new energy enterprises created a remarkable performance. At the same time, it also triggered some new energy enterprises to rely too much on government subsidies, and even the existence of "subsidy fraud" behavior. For this reason, China's government subsidy policy for new energy enterprises has been adjusted accordingly, such as raising the subsidy threshold and reducing the subsidy amount. According to the "notice on improving the financial subsidy policy for the promotion and application of new energy vehicles", China ended the new energy vehicle purchase subsidy policy before December 31, 2022, intensifying the market competition faced by China's new energy automobile industry. The development mode of the automobile industry will be changed.

Do government subsidies help new energy firms improve their business performance? What is the effect of R&D investment on business performance? If both exist at the same time, what will be the impact on business performance? This paper will answer these questions through the following research.

2. LITERATURE REVIEW AND RESEARCH HYPOTHESIS

2.1 R&D Investment and Business Performance of New Energy Companies

In recent years, whether in the academic or business community, government agencies, have gradually recognized the importance of scientific performance evaluation of enterprise R&D investment, through accurate evaluation, can not only find out the defects of the enterprise in R&D investment but also can quickly improve the enterprise in the scientific and technological innovation of the profits, so that the performance of the enterprise has been improved. Research and development investment, that is, the enterprise's investment in product technology, in the development, and other aspects of the various costs incurred, generally consists of research and development personnel salary costs, direct input costs, depreciation, long-term amortization costs, design costs, equipment debugging, amortization costs of intangibles and so on. If an enterprise's R&D investment is successful, the new technology invested in by the R&D can reduce the cost of the original technology, increase the competitiveness of the product in the market and market share, and thus improve business performance.

Zhuang Wanting et al. [1] used all SME-listed companies from 2012-2016 as the initial sample specimen and used empirical analysis to conclude that corporate R&D investment showed a significant negative correlation with business performance without considering the effect of government subsidies [1]. Zhao Xingming et al. [2] found that corporate R&D investment is negatively related to short-term financial performance and positively related to long-term market performance by constructing a model validation [2]. Wang Xinhong and Nie Yaqian [3] pointed out that R&D investment is conducive to the improvement of business performance, but the positive promotion effect on state-owned enterprises is significantly weaker than that of private enterprises, as well as listed companies in the Northeast and Western regions, and R&D investment does not have a significant positive impact on business performance [3]. Wang Xi et al. [4] pointed out with the help of panel data that R&D investment in manufacturing enterprises promotes innovation performance, and R&D investment has a positive moderating effect on business performance [4]. Cao Yang and Yi Qiqi [5] argued that appropriate R&D investment can improve the financial performance of enterprises, and R&D investment has a lagging effect on business performance [5].

R&D investment is the source of life of scientific and technological innovation, in the new energy enterprise market, these many companies are the main force of scientific and technological innovation, and want to improve business performance, you need to invest certain resources in project research and development. However, for some small and medium-sized enterprises, due to the relatively small size of the enterprise, the enterprise funds are not sufficient, if a substantial increase in R&D investment in the project funds, will relatively reduce the enterprise in other projects, in this case, the company's huge R&D investment will bring the burden of the enterprise, in the short term is difficult to improve business performance.

Hypothesis 1: there is a positive relationship between R&D investment and the business performance of new energy enterprises.

2.2 Government Subsidies and Business Performance of New Energy Enterprises

Government subsidies are an important tool and means for the government to participate in macroeconomic regulation and control, and more and more enterprises have benefited from this in recent years, and new energy enterprises are no exception. To innovate, enterprises must continuously invest huge sums of money, but because research and development are characterized by long-term uncertainty, the return of funds is slow, there is a certain externality in the results of research and development, and the enthusiasm of enterprises is not high, which requires the government to support the enterprises in terms of funding. Wang Linxia [6] used the data analysis during 2014-2018 to conclude that a large number of subsidies directly promoted enterprises to carry out technological innovation, and new technologies and products also brought profit improvement [6]. Xia Ling [7], on the other hand, argues that government subsidies are an external source of funding for enterprises to make R&D investments, which is crucial for their research and development innovation [7].

The government grants financial subsidies to enterprises with the initial intention of promoting the enhancement of innovation ability, stimulating the enthusiasm of enterprises to develop new technologies, and developing new products to increase the sales income of enterprises, but whether enterprises can achieve the effect of improving business performance through government subsidies has always been a topic for discussion.

Hypothesis 2: there is a positive relationship between government subsidies and the business performance of new energy enterprises.

2.3 R&D Investment, Government Subsidies and Business Performance of New Energy Enterprises

Government subsidies affect the R&D investment of enterprises, and the increase of R&D investment can promote the enhancement of the innovation ability of enterprises and stimulate enterprises to develop new technologies and new products to increase the sales revenue of enterprises. Therefore, in this paper, when studying the relationship between the three factors of government subsidies, R&D investment, and business performance, it is necessary to first test whether the interaction effect occurs when R&D investment and government subsidies exist simultaneously. Chai Yuan [8] pointed out that enterprise R&D investment belongs to the mediating variable and has a mediating effect, so improving business performance can start from both increasing government subsidies and expanding enterprise innovation investment [8]. Jing Tingru and Cheng Zixuan [9] used causal step-by-step analysis to test the mediating role of R&D investment and used the Bootstrap method to verify the relationship between R&D investment, government subsidies, and business performance again, and the results obtained by the two methods were the same, and it was concluded that R&D investment played a part of the mediating effect [9]. Wang Nan et al. [10] found that for the new energy industry, government subsidies have a strengthening effect on the negative correlation between R&D investment and short-term performance, while the correlation between government subsidies and R&D investment and long-term performance is not significant. [10]

Many scholars in China believe that the interaction effect occurs when R&D investment and government subsidies coexist in enterprises. Government subsidies in the form of funds to promote enterprises to increase investment in R&D projects, and promote the improvement of the enterprise's innovation capacity, thus making continuous improvement in business performance.

Hypothesis 3: there is a positive effect of the interaction effect between firms' R&D investment and government grants on business performance.

3. MATERIALS AND METHODS

3.1 Research Design

3.1.1 Data Sources and description of variables

This paper selects the data related to new energy enterprises listed companies in 2017-2021, covering a variety of industry sectors such as new energy vehicles, solar energy, wind power, nuclear energy, energy saving, and

environmental protection. This paper refers to the specific practice of the study of Shi Junguo et al. [11], and the initial sample specimen is processed as follows: firstly, to ensure the validity and completeness of the sample exclude ST, ST companies; secondly, exclude the companies that are closely related to the empirical analysis of this paper, but the disclosure of the indicators of R&D inputs, the number of researchers, and government grants is incomplete [11]. After the screening process mentioned above, the financial statement data of 53 new energy-listed companies for 2017-2021, totaling 265 samples, were finally collected through the CSMAR (China Stock Market & Accounting Research Database).

3.1.2 Dependent variable

The dependent variable is business performance. Most foreign scholars choose Tobin's Q to measure operating performance, and due to the lack of maturity of China's capital market, the prerequisites for the use of Tobin's Q have not been met. In addition, China's new energy-listed companies generally have a high gearing ratio, which leads to the fact that enterprises can not get enough financial support, thus affecting the development and innovation of enterprises. Therefore, this paper takes the research design of Wang Nan et al. [10] as a reference, selects financial indicators to measure the operational performance, and takes the enterprise's return on total assets (ROA) as a measure of the operational performance of new energy listed companies [10]. Because ROA is an important indicator to measure the profitability of the company's assets, ROA is good if the trend is smooth or rising, the two main drivers of ROA are net profit margin and total asset turnover, return on total assets ROA is the return on net profit measured based on shareholders' equity and liabilities, which measures the effect of the output of the invested total assets, and the higher the ratio, the more it can show that the company's profits are high and the asset utilization rate is higher, i.e., the new energy companies have a higher profit and higher asset utilization rate. The higher this ratio is, the more it shows that this company has high profits and a high asset utilization rate, i.e. the better the business performance of the new energy enterprise.

3.1.3 Independent variables

The main independent variables in this paper are research and development investment (RD) and government subsidy (Sub). All data can be obtained from the CSMAR (China Stock Market & Accounting Research Database). However, the impact of the same government subsidies or the same enterprise R&D investment is different for enterprises of different sizes. To more accurately reflect the government's support for enterprises and the intensity of enterprise R&D investment, this paper adopts the intensity of government investment (RD), i.e., the ratio of R&D investment to business revenue, to measure R&D investment, and the larger the ratio value indicates that the intensity of the company's R&D investment is larger; the intensity of government subsidy (Sub), i.e., the ratio of government subsidy to total value of enterprise's assets, is also used. The intensity of government subsidies (Sub), i.e., the ratio of government subsidies to the total value of corporate assets, is used to measure the government subsidy index of the enterprise, and the larger the ratio is, the more government subsidies the new energy company has.

3.1.4 Control variables

In this paper, the enterprise's gearing ratio (Lev), enterprise size (Size), capital intensity (CI), operating profit ratio (OPR), and the age of new energy enterprise enterprises (Age) are selected as control variables.

The gearing ratio (Lev) is a comprehensive indicator of a company's level of indebtedness, which reflects the status of the company's capital structure, expressed as the ratio of liabilities to total assets.

Different enterprise sizes, their business performance tends to be different, this paper selects the natural logarithm of the total assets at the end of the period to measure the enterprise size, analyzed from the financial point of view, large-scale new energy enterprises have more room to research and develop technology, and the R&D investment is larger, while small and medium-sized enterprises due to the small size, insufficient funds, and other reasons, the investment in enterprise R&D is relatively low.

In this paper, we refer to Ba Shusong et al. [12] to add the control variable capital intensity (CI) [12], which is expressed as the ratio of fixed assets to operating income, the higher the capital intensity, the higher the risk, and the higher the cost of capital, then, the more the conditions are in place to create higher labor productivity.

Operating Profit Ratio (OPR) is the proportion of operating profit in the operating revenue of an enterprise. It is mainly used to measure the level of operating profit realized by the enterprise in a certain period, which is a kind of assessment standard for the economic efficiency of an enterprise. This indicator is a comprehensive reflection of the operational efficiency of the enterprise and also reflects the management level and management ability of the enterprise. Operating profit margin can be used as a measure of an enterprise's profitability standard. The higher the operating profit margin, the more it can show that the enterprise manager of the enterprise management and management ability, the enterprise made more operating profits, the company's profitability is stronger; on the contrary, the lower this indicator, indicating that the enterprise's profits are lower, the worse the profitability.

In this paper, we refer to Su Yi et al. [13] to add the age of new energy enterprises and the cumulative listing year of listed companies to the control variables [13]. Because new energy early mastered less research technology first pairs, it is unable to improve the innovation ability of the enterprise significantly, while the emerging new energy enterprises are likely to invest more in R&D expenditures.

3.2 Descriptive Statistics

Table 2 shows the descriptive statistics of the variables in the model. As can be seen from Table 2, the data distribution of return on total assets (ROA) is more dispersed, with an extreme deviation of 52.02 and a large standard deviation of 6.857, indicating that the development of each company in the new energy enterprises in the past five years has been uneven, and it must be emphasized. Among the new energy listed companies R&D investment intensity spans a large, extreme difference of 26.200, with a standard deviation of 3.034, indicating that there are significant differences in the intensity of R&D investment in the new energy industry of the companies, the majority of companies in the enterprise innovation and research and development of the investment of funds is less. From the perspective of the industry, new energy companies in the enterprise in the R&D investment show obvious right bias characteristics, and most of the business performance is at a lower level. The government should take measures to incentivize such enterprises to increase their R&D investment and improve their innovation ability and market competitiveness. The mean value of R&D investment is 4.141, indicating that the intensity of R&D investment of the sample new energy enterprises shows a left-skewed distribution in general, and the R&D investment of the enterprises is relatively small, and only individual companies have invested more funds for enterprise innovation and R&D. By observing the data on the intensity of government subsidies, it can be seen that there is not much difference in government subsidies among enterprises, and

Table 1. Variable symbols and descriptions

Variable type	Name	Notation	Variable Definition
dependent variable	Operating performance	ROA	net profit/total assets
independent variables	R&D investment intensity	RD	R&D investment/operating income
	government subsidy intensity	Sub	government subsidies/total value of assets
	intermodal term	Sub*RD	the cross multiplier of government subsidies and R&D investment
control variables	asset liability ratio	Lev	ratio of total liabilities to total assets
	enterprise size	Size	The natural logarithm of total assets at the end of the year
	capital intensity	CI	fixed assets/operating income
	operating profit ratio	OPR	operating profit/operating income
	enterprise age	Age	years of listing of new energy enterprises

Source: *CSMAR (China Stock Market & Accounting Research Database)*

deviation of 0.045. Compared with the results of other scholars' studies in previous years, we can find that the government's subsidies for new energy enterprises have been reduced in recent years, and there is not a large gap in government subsidies for enterprises with different research directions.

Through the study of other control variables can be found, that the maximum value of the sample company's gearing ratio is 86.4%, the minimum value is 7.6%, and the extreme difference is 0.788, which is a large difference, which indicates that the new energy enterprise's asset structure varies greatly between enterprises, and the assets are more disparate. The average value of enterprise size is 23.329, and the difference between its maximum value and minimum value is 7.536, which indicates that the size of individual enterprises in new energy enterprises varies greatly, and the development structure of the whole industry is still not stable enough. The average value of capital intensity is 1.193, the standard deviation is 1.543, and the extreme deviation is 6.503, the standard deviation is relatively small, indicating that the capital intensity of different enterprises does not differ much, that is, the gap between the capital structure of different industries in new energy enterprises is relatively small. Comprehensive observation of operating profit margins shows that the operating profit margins of the selected sample companies are low, indicating that the overall operating performance of new energy enterprises is not high, and in general, the corporate profitability of new energy enterprises is weak, and there is still a lot of room for progress and development. By observing the enterprise age variable, it can be seen that the extreme difference of this variable is 32 years, indicating that there are two extremes in the development of new energy enterprises, one is the new energy enterprises developed in the nineties, and the other is the enterprises that have gradually emerged in recent years, which may be one of the important reasons for the uneven level of development of the new energy enterprises among the companies.

Table 2. Descriptive statistics of variables

variant	sample size	average value	standard deviation	minimum value	maximum values
ROA	265	6.894	6.857	-15.002	37.018
RD	265	4.141	3.034	0.000	26.200
Sub	265	0.004	0.004	0.000	0.045
Lev	265	0.533	0.166	0.076	0.864
Size	265	23.329	1.586	19.203	26.739
CI	265	1.193	1.543	0.021	6.524
OPR	265	0.119	0.135	-0.542	0.456
Age	265	13.450	7.739	-4.000	28.000

3.3 Modeling

In this paper, the panel data fixed effects model is used for the study, and the following three models are constructed according to the purpose of the study:

Model 1:

$$ROA_{it}=\beta_0+u_i+\lambda_t+\beta_1\cdot RD_{it}+\beta_2\cdot\sum Control_{it}+\varepsilon_{it} \quad (1)$$

Model 2:

$$ROA_{it}=\beta_0+u_i+\lambda_t+\beta_1\cdot Sub_{it}+\beta_2\cdot\sum Control_{it}+\varepsilon_{it} \quad (2)$$

Model 3:

$$ROA_{it}=\beta_0+u_i+\lambda_t+\beta_1\cdot Sub_{it}+\beta_2\cdot RD_{it}+\beta_3\cdot Sub_{it}\cdot RD_{it}+\beta_4\cdot\sum Control_{it}+\varepsilon_{it} \quad (3)$$

Where β_0 is the intercept term; ε_{it} is the random error term; β_1、β_2、β_3、β_4 is the model regression coefficients; i denotes the ith new energy sample company, and t denotes the tth year. Combined with the existing research and data operationalization, this paper selects the gearing ratio (Lev), firm size (Size), capital intensity (CI), operating profit ratio (OPR), and age of the firm (Age) as the control variables, and also adds firm-level fixed effects (u_i) and year fixed effects (λ_t).

To test hypothesis 1, this paper constructs model 1 by considering operating performance (ROA) as the dependent variable, R&D investment intensity (RD) as the independent variable, and gearing ratio, firm size, capital intensity, operating profit margin, and firm age as the control variables.

To test hypothesis 2, this paper constructs model 2 with operating performance (ROA) as the dependent variable, government subsidy intensity (Sub) as the independent variable, and gearing ratio, firm size, capital intensity, operating profit margin, and firm age as the control variables.

To test hypothesis 3, this paper takes operating performance (ROA) as the dependent variable, government subsidy intensity (Sub), R&D investment intensity (RD), and the cross-multiplier of government subsidy and R&D investment (Sub*RD) as the independent variable. The gearing ratio, enterprise size, capital intensity, operating profit margin, and age of the enterprise are control variables. Drawing on the study of Sun Hui and Wang Hui (2017), the interaction term of Sub and RD (Sub*RD) is introduced for model construction, where Sub and RD are the main effect terms and Sub*RD is the interaction effect term. If the coefficient before the interaction term is a positive (negative) value, it indicates that the interaction effect of government subsidies and R&D investment has a positive (negative) impact on operating performance.

4. EMPIRICAL ANALYSIS

4.1 Correlation Analysis

Table 3 shows the Pearson's coefficients of the variables, which allows us to determine whether there is a correlation between the variables.

4.1.1 Correlation between R&D intensity and business performance

As shown in Table 3, there is a positive correlation between the intensity of R&D investment (RD) and the operating performance (ROA) of new energy enterprises, indicating that the enterprise R&D investment can play a positive moderating role on the operating performance of new energy enterprises, but the results are not significant, and this effect will be further analyzed later. Observing other variables, the correlation coefficients between corporate R&D investment and corporate gearing (Lev), enterprise size (Size), and capital intensity (CI) are significantly negative, indicating that when the financial leverage of listed companies of new energy enterprises is greater, the larger the enterprise size is, and the greater the capital intensity is, the lower the enterprise's investment in R&D and innovation technology is. The correlation coefficients between RD and the age of enterprises are significantly negative at the level of 5%, indicating that corporate R&D investment can play a positive role in regulating the business performance of new energy enterprises. 5% level is significantly negative, which indicates that startups may be more focused on improving corporate innovation capability and innovation talent cultivation, and therefore invest relatively more funds in R&D.

4.1.2 Relevance of government grants to operating performance

As shown in Table 3, the correlation coefficient between government subsidies (Sub) and operating performance (ROA) is 0.3172, which is significantly positive at the 1% level, indicating that there is a crowding-in effect of government subsidies on the operating performance of new energy enterprises, and when the government increases the subsidy funds for new energy enterprises, the performance of the enterprises will also be improved. In addition, enterprise R&D investment and government subsidies are significantly positively correlated at the 1% level, which indicates that a certain amount of government subsidies can motivate enterprises to increase their R&D investment, promote the innovation ability of new energy enterprises, and improve their competitiveness.

Table 3. Table of correlation coefficients of main variables

variant	ROA	Sub	RD	Lev	Size	CI	OPR	Age
ROA	1.0000							
Sub	0.3172	1.0000						
RD	0.0951	0.3713	1.0000					
Lev	-0.4318	-0.3219	-0.3630	1.0000				
Size	-0.3672	-0.4488	-0.3333	0.6075	1.0000			
CI	-0.1594	-0.3246	-0.4146	0.2595	0.3828	1.0000		
OPR	0.7188	-0.0497	-0.0960	-0.2602	-0.0218	0.3365	1.0000	
Age	-0.3466	-0.2089	-0.1671	-0.1910	0.2090	0.4849	0.0592	1.0000

*The coefficients in the table are Pearson's correlation coefficients, and ***, **, and * indicate significance at the 1%, 5%, and 10% statistical levels, respectively*

4.2 Regression Analysis

4.2.1 Relationship between R&D investment and business performance

The second column in Table 4 shows the regression results of research and development investment (RD) and return on total assets (ROA) of new energy enterprises. By observing the data in the table, it is noteworthy that there is a significant positive correlation between R&D investment and business performance of new energy enterprises, with a coefficient of 0.2706194 and a t-value of 1.64, i.e., the regression coefficient is significantly positive at the 10% level, which indicates that the increase in the intensity of R&D investment effectively improves the business performance without taking into account the influence of government subsidies, thus also confirming the hypothesis 1 of this paper, which holds that There is a positive correlation between corporate R&D investment and business performance of new energy enterprises. According to the value of the regression coefficient, for every unit increase in R&D investment, operating performance rises by 0.2706194 units on average, indicating the effectiveness of high R&D investment in enterprises to create high operating performance, which supports the mainstream view.

At the same time, there is also a significant negative correlation between enterprise size and business performance at the 5% level, which indicates that the larger the enterprise size, the worse the business performance of new energy enterprises; there is a positive correlation between the gearing ratio (Lev), capital concentration (CI), operating profit rate (OPR), enterprise age (Age) and business performance, gearing ratio at the 5% level has a significant positive impact on business performance, which indicates that the larger the financial leverage, the better the business performance; the enterprise's operating profit margin and business performance at the 1% level there is a significant positive correlation and a larger coefficient of 41.5. The gearing ratio has a significant positive effect on business performance at the 5% level, which indicates that the greater the financial

Table 4. Full sample regression results

variant	Model 1	Model 2	Model 3
Sub	--	103.5267 (1.96)	33.93926 (0.22)
Sub*RD	--	--	6.767171 (0.47)
RD	0.2706194 (1.64)	--	0.1752402 (0.71))
Lev	7.675632 (2.34)	6.440284 (1.78)	7.284597 (2.25)
Size	-2.063744 (4.62)	-1.836626 (-1.71)	-1.863373 (-1.65)
CI	0.0274929 (0.15)	0.0313945 (0.16)	0.0330083 (0.17)
OPR	41.22512 (11.93)	39.80021 (9.06)	40.90849 (11.87)
Age	0.1595317 (0.81)	0.1294003 (0.71)	0.1205422 (0.64)
_cons	43.93536 (1.68)	40.48198 (1.72)	39.95728 (1.61)
$\overline{R}^2$	0.6256	0.6364	0.6360
id	YES	YES	YES
Year	YES	YES	YES

*t-test values in parentheses, *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively*

leverage, the better thebusiness performance; the operating profit margin of the enterprise has a significant positive correlation with business performance at the 1% level and the coefficient is larger, with a value of 41.22512,which indicates that the higher the operating profit margin is, the better the business performance is; of the regression results, the rho of the regression results is 0.68880629, which indicates that the majority of the variance of u_i and ε_{it} comes from the change of the individual effect. from the variation of the individual effect u_i.

4.2.2 Relationship between government subsidies and operating performance

The third column shows the regression results of government subsidies (Sub) and return on total assets (ROA). The adjusted R^2 in the regression results of Model 2 is 0.6364 with an F-value of 16.90, which is a good fit. The data in the table illustrates that there is a positive correlation between government subsidies and operating performance, with a correlation coefficient of 103.5267, which is significantly positively correlated with operating performance at the 10% level, and a t-value of 1.96, which suggests that government subsidies have a signaling attribute that can bring resources to the company. The amount of government subsidies received by a company can better reflect the development prospects of the industry and the degree of government recognition of the company, but also better signal to the outside world that the relationship between the company and the government is close or not. The government subsidy is an unfair competitive advantage gained by directly affecting the economic rent obtained by the firm, which in turn helps the firm to improve its innovation performance in the short run. The results obtained support hypothesis 2 of this paper, which states that government subsidies have a facilitating effect on the business performance of new energy firms.

4.2.3 Relationship between R&D investment, government grants, and operating performance

The fourth column of data in Table 4 shows the regression results of government subsidies (Sub), R&D investment (RD), and the operating performance (ROA) of new energy firms. The cross-multiplier term of government subsidy and R&D investment is added to this model to examine the interaction effect of R&D investment and government subsidy in the firms. The results in Table 4 show that both government subsidies and R&D investment have positive effects on business performance, and government subsidies are more favorable to business performance than R&D investment.

The coefficient of the cross-multiplier term of Sub and RD is positive, indicating that when R&D investment and business performance coexist in the enterprise, the interaction effect triggered by the two plays a positive moderating effect on business performance. Still, the promotion effect of both on business performance has been weakened. In general, these three explanatory variables have a positive effect on business performance, and accordingly, hypothesis 3 of the present study has been tested. In terms of other control variables, the effects of each variable on operating performance are consistent with those discussed in the previous section, indicating that the regression results are relatively robust and consistent with the corresponding significance and correlation in Models 2 and 3.

4.3 Robustness Tests and Further Analysis

4.3.1 Robustness Tests

To test the stability of the model and the reliability of the results, this study conducted a robustness test by replacing the explanatory variables, using return on equity (ROE) as an indicator of the operating performance of new energy enterprises, and repeating the above steps after replacing ROA with ROE to do the same regression analysis. The regression results show that both government subsidies and corporate R&D investment have a positive impact on the operating performance of new energy enterprises, which is consistent with the main regression conclusion. However, in the third model, the coefficient before the cross-multiplication term of government subsidies and R&D investment is negative, contrary to the main regression, to verify the reliability of the results of this paper, this paper will conduct further analysis.

4.3.2 Further analysis

Since R&D activities usually take up to a year or more, many scholars have suggested that the full

effect of subsidies cannot be fully revealed in the short term and that the impact of subsidies is not instantaneous but has an effect on the subsequent period. To test the time-lag structure of corporate R&D investment and government subsidies on the business performance of new energy firms, this paper examines the interaction term of Sub and RD lagged by one to three periods.

The second to fourth columns of Table 6 are the results of lagging the interaction term of Sub and RD from one to three periods, respectively, and the results show that: in the case of lagging one period the interaction term of Sub and RD still hurts operating performance, and when lagging two periods the regression coefficient is positive, i.e., Sub*RD is significantly positively correlated with return on equity (ROE), and in lagging three periods, the regression coefficient of the cross-multiplication term of government subsidies and firms' R&D inputs is significantly positive at the 1 percent level. The regression coefficient of the cross-multiplier term of government subsidies and enterprise R&D investment is significantly positive at the 1% level, with the lowest t-value of 4.11. From this, it can be concluded that the stimulating effect of the interaction effect between government subsidies and enterprise R&D investment on return on equity (ROE) is generally after one year, and the effect after one year is promotion, and the regression coefficient of the cross-multiplier term is gradually increasing at lags one to three, which indicates that the effect of the interaction between Sub and RD on ROE is getting better and better year by year.

Table 5. Robustness test regression results

variant	Model 1	Model 2	Model 3
Sub	--	160.4877 (1.27)	178.3614 (0.47)
Sub*R&D	--	--	-12.37698 (-0.33)
R&D	1.159173 (2.01)	--	1.224384 (1.49)
Lev	31.48495 (3.75)	26.91122 (2.67)	31.19761 (3.84)
Size	-2.053418 (-0.74)	-1.582493 (-0.57)	-1.975854 (-0.74)
CI	0.1187516 (0.36)	0.1104658 (0.38)	0.1277885 (0.38)
OPR	104.6186 (7.18)	98.51346 (5,38)	104.6237 (7.33)
Age	-0.1058012 (-0.21)	-0.1289636 (-0.26)	-0.1210002 (-0.25)
_cons	24.92994 (1.40)	21.68005 (0.36)	22.70867 (0.38)
$\overline{R}^2$	0.5968	0.5520	0.6044
id	YES	YES	YES
Year	YES	YES	YES

*t-test values in parentheses, *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively*

Table 6. Fixed effects test lagged one to three results of Model 3

variant	Return on Equity ROE		
	one period behind	Two periods behind	three-phase lag (in technology)
Sub	256.7238 (1.37)	591.466 (2.12)	264.2763 (1.36)
l.Sub*RD	-23.03475 (-2.94)	--	--
l2.Sub*RD	--	67.4246 (1.97)	--
l3.Sub*RD	--	--	150.2353 (4.11)
RD	1.097859 (2.00)	1.000448 (0.76)	0.1773831 (0.20)
Lev	18.60683 (2.06)	17.57682 (2.48)	6.090894 (0.61)
Size	2.088948 (0.69)	-0.0242021 (-0.01)	-1.23789 (-0.22)
CI	-1.255633 (-1.02)	-1.837822 (-0.87)	-1.574983 (-1.39)
OPR	108.4652 (5.90)	116.6004 (7.24)	97.24829 (6.79)
Age	-0.3541102 (-0.61)	-0.1252594 (-0.14)	-1.342874 (-1.30)
_cons	-63.53411 (-0.96)	-18.36966 (-0.20)	32.45921 (0.27)
$\overline{R}^2$	0.5372	0.5673	0.4233
id	YES	YES	YES
Year	YES	YES	YES

*t-test values in parentheses, *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively*

In summary, there are positive moderating effects of both government grants and R&D investment on operating performance, and the positive effects of the interaction of the two will come into play after one to two periods, which are broadly consistent with the findings of the main regression.

5. RESULTS AND DISCUSSION

5.1 Results of the Study

This paper takes the industry of new energy enterprises as a research sample, selects the data from 2017-2021 to carry out empirical research, and finally draws the following results:

First, appropriately increasing enterprise R&D investment can effectively improve the business performance of new energy enterprises, and improve the company's technological innovation ability, thus stimulating the increase of enterprise R&D investment, stimulating the enthusiasm for enterprise innovation, improving the company's core competitiveness, expanding enterprise market share, and improving the profitability of the enterprise, i.e., it has a certain positive impact on the business performance. This conclusion verifies hypothesis 1, that is, there is a positive correlation between R&D investment and the business performance of new energy enterprises.

Second, the relationship between government subsidies and operating performance is positively correlated, with some government subsidies.

It can motivate enterprises to improve their innovation ability, and at the same time, it will have a certain positive effect on the improvement of business performance, by increasing the government subsidies to new energy enterprises to improve the awareness of independent innovation and improve the profitability of enterprises. This conclusion verifies hypothesis 2 that government subsidies can improve the business performance of new energy enterprises.

Third, the interaction effect generated between corporate R&D investment and government subsidies will have a certain degree of positive impact on the business performance of new energy enterprises. Through the empirical research analysis in this paper, there is a positive relationship between Sub*RD and ROA, and in the robustness test, the analysis shows that the cross-multiplier term plays a significant positive impact on ROE at lag two, and the promotion effect of Sub*RD on ROE shows more significant at lag three. It indicates that both government subsidies and corporate R&D investment can enhance operating performance, but when both exist at the same time, the positive promotion effect is weakened, at this time, the government subsidies have a better effect on the promotion of operating performance. This conclusion verifies hypothesis 3 that the interaction effect between R&D investment and government subsidies has a positive impact on business performance.

6. CONCLUSION

6.1 Suggestions to the Government

First, the intensity and direction of government subsidies should be clarified. The government should improve the relevant laws and regulations, strengthen supervision and management, and provide enterprises with a fairer and more transparent information platform so that enterprises can better carry out independent innovation. In recent years, many enterprises have faced the problem of "cheating subsidies", under the pretext of increasing enterprise innovation, borrowing government subsidies to make up for the loss, and whitewashing the profit [14]. Therefore, the government should change the way of direct subsidies, through tax incentives and other ways to indirectly subsidize new energy enterprises, which can appropriately reduce the dependence of some enterprises on government subsidies. At the same time, the government's government subsidies to enterprises can do "a small number of times", you can increase the number of government subsidies to new energy enterprises each year, while appropriately reducing each time the subsidies to the enterprise funds, through the issuance of government subsidies many times, and constantly stimulate innovation, always reminding the enterprise to put scientific and technological innovation in the first place, and always maintain the spirit of innovation, stimulate enterprises to increase investment in research and development. The spirit of innovation stimulates enterprises to increase investment in research and development and improve innovation capacity.

Secondly, the government should appropriately raise the threshold for enterprises to obtain

government subsidies, and enterprises applying for government subsidies can be prioritized to enjoy government subsidies if there is a significant improvement in their performance, in addition, the number of government subsidies can be appropriately increased according to the situation, which is more likely to stimulate enterprises to apply for subsidies for innovation, and to enhance the enthusiasm of enterprises to innovate, which has led to the development of new energy enterprises in a prosperous manner.

Finally, the government needs to establish a perfect information disclosure system, and timely release of government subsidy data to the community, so that the public can clearly understand the actual operating conditions of enterprises, at the same time, should continue to improve the management and supervision system of new energy enterprise financial support, strengthen the supervision and formulation of perfect laws and regulations, clearly defining the standards and scope of subsidies for enterprises to obtain subsidies as well as the conditions of subsidies for enterprises to provide enterprises with More reasonable and effective policy guidance. Push subsidies in a targeted manner, establish a special account, set up government subsidy funds only for enterprise innovation, so that enterprises can use all the money to the "blade" up, and constantly monitor the movement of the subsidies, real-time supervision of government subsidy funds for each enterprise, to prevent enterprises from abusing them, and at the same time to increase the penalties for violating the provisions of the enterprise. Penalties should also be increased for enterprises that violate the rules.

6.2 Suggestions to Enterprises

Enterprises should strengthen their awareness of independent innovation. To gain long-term competitive advantage, enterprises must have continuous innovation. For an enterprise, innovation is the primary way to shorten the growth cycle and obtain sustainable development. To obtain long-term development, enterprises must rely on technological innovation to drive industrial upgrading. In this era of fierce competition, who can innovate, and who can seize the first opportunity? As an emerging industry, the new energy industry plays an important role in the development of the national economy and is one of the key areas of the national economic development strategy. Every enterprise should put science and technology innovation in the foreground, science and technology is the first productive force, and innovation is the primary driving force for the forward development of enterprises. Enhancing the ability to innovate, is the future of new energy this industry development trend, increases innovation, can reduce the core cost of enterprises, optimizes the core performance of enterprises, and ultimately increases the level of profitability of enterprises.

Enterprises should standardize the disclosure of the use of government subsidies. Because many enterprises have "cheating" behavior, the government subsidies are used to make up for the company's losses, profit, and income, which makes many enterprises cancel the government subsidy policy. And for the enterprise itself, should regulate its own, many companies always simply disclose the amount of government subsidies and R&D investment in the information, and no detailed description of the accompanying financial statements, which is not sufficient to explain how the enterprise uses the government subsidies. Therefore, any new energy enterprises should first standardize the use of government subsidies to disclose in detail, to provide more detailed information to the public, so that everyone can fully understand how the enterprise is the use of these government subsidies, which also makes the government subsidies carry out the policy more smoothly.

6.3 Recommendations for Future Research

Due to the limitations in information acquisition, some companies' data on RD and Sub for 2017-2021 are missing, and this paper had to round them off, resulting in a reduced sample size, and the results of the empirical study may be biased to a certain extent. If relevant data on all new energy enterprises, including listed and non-listed companies, can be obtained, and all data will be used for future research, the results will be more scientific and rigorous.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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