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Research on Government Environmental R&D Subsidies, Green Innovation Investment and Corporate Financial Performance: A Case Study of Listed Electric Power Enterprises

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Abstract

In recent years, with multiple studies showing a clear link between a country's economic development and its environmental pollution, whether the government's environmental R&D activities can guide innovation and improve the financial performance of enterprises has become a hot issue in the field of innovation. However, most of the existing studies are limited to the impact of corporate governance characteristics on financial performance, or the pairwise relationship between government subsidies, R&D investment and financial performance. There is still a lot of space for exploring the relationship between government's environmental R&D subsidies and corporate financial performance, as well as the mediating effect of green innovation investment. Based on information asymmetry theory, signal transmission theory, externality theory and sustainable development theory, this paper conducts multiple regression analysis on the data of 46 listed power companies in China from 2015 to 2021, with tests of robustness. The results show that: government environmental R&D subsidies have a positive contribution to both corporate financial performance and green innovation investment, and green innovation investment plays a partial intermediary role between government environmental R&D subsidies and corporate financial performance.

Keywords

Government Environmental R&D Subsidies; Green Innovation Investment; Corporate Financial Performance; Electric Power Enterprises; Environmental Protection R&D Investment; R&D Personnel.

1. Introduction

For a long time, China has taken self-reliance of science and technology as an important direction of national development, continued to implement the innovation-driven development strategy in depth, and vigorously build an innovative and strong country. By making an unprecedented investment in science and technology, we successfully entered the ranks of innovation-oriented countries. National development cannot be separated from enterprises. With today's increasing environmental problems, green innovation has become the primary task during the development of modern enterprises. With the support of research and development on environmental technology, pollution and energy consumption can be reduced while synchronous growth in economic performance can be established.

However, as a major issue, green innovation cannot be fully supported by the financial ability of the enterprise itself, and because of the public nature of R&D activities, it needs government subsidies. In other words, enterprises' green transformation needs to be realized through both self-financing, internally, and targeted R&D subsidies from the government, externally. In recent years, the objects of government subsidies in China are mainly concentrated in the fields of Technology R&D and innovation investment. Specifically, enterprise innovation is highly

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encouraged by annually increased government subsidies. Through issuing environmental R&D subsidies, government can regulate the outcome of environmental protection, which improves enterprises' capability of R&D activities alleviate their financial burdens. Prevention of the potential market failure of R&D activities can then counteract the excessive external costs and improve financial performance. Therefore, studying relationships between government subsidies in the field of environmental protection, the investment in green innovation and the financial performance of enterprises has become topic of interest in current research.

As one of the pillar industries of the national economy, the power industry has strongly supported the rapid development of the economy and society. At the same time, as the key enterprises in achieving the environmental protection goal, the green transformation is of great significance. However, simply relying on traditional power generation can no longer meet the needs of ecological and environmental protection. Electric power enterprises must increase investment in green innovation, especially in the development of environmental protection equipment, and clarify the relevant impact of government environmental R&D subsidies on enterprise performance under the role of enterprises' own investment in green innovation.

In the case that the existing research mostly focuses on the relationship between government subsidies and financial performance, this paper aims to combine the internal and external factors of enterprises, explore the relationship between government environmental R&D subsidies and financial performance of enterprises, try to find the mediating effect of green innovation investment, that is, analyze whether electric power enterprises can improve their financial performance through independent green innovation under the condition of obtaining government environmental R&D subsidies from the internal perspective of enterprises, while studying how to use environmental R&D subsidies to improve their financial performance from the external perspective.

Based on the above and existing research, this paper intends to select qualified power listed companies from the latest industry classification of CSRC, taking the power industry as the screening standard, and explore its influence on the financial performance of power listed companies from the external factor of government environmental protection R&D subsidies. Then, the influence of subsidy on the environmental protection behavior of such enterprises is analyzed by the information asymmetry theory, signal transmission theory, externality theory and sustainable development theory, verifying the intermediary role of enterprise green innovation investment. The investment plays certain theoretically complementary role for the correlation study between government subsidies and enterprise financial performance in the field of environmental protection research and development, which has practical significance.

2. Literature Review

There are abundant studies on the relationship between government subsidies and financial performance of enterprises at home and abroad. In the Welfare Economics originally published in 1920, Pigou (1920) redefined economics as an economic welfare science. In the process, he developed the first systematic theory on market failure, that is, it is reasonable for the government to intervene in the originally unconstrained market; Jenkins et al. (2006) studied the data of American high-tech enterprises and concluded that the supportive policies introduced by the government are conducive to the improvement of financial performance. Taking ownership into account, Jin et al. (2018) found that government subsidies could improve the current performance of manufacturing enterprises, and government subsidies had a more significant positive impact on innovation investment and financial performance of private enterprises than state-owned enterprises. By sorting out the research of enterprises in different industries and with different property rights, this paper finds that the research conclusions of all walks of life are not consistent on the effect of government subsidies on

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financial performance, but most scholars believe that government environmental research and development subsidies have a positive impact on corporate financial performance, and the impact is significant.

At present, the research on investment in green innovation is still in its infancy. The concept of green innovation originated from the definition given by foreign scholar Braun and Wield (1994), which means that enterprises aim at reducing environmental pollution, while minimizing the consumption of raw materials and energy, developing or improving new technologies, processes or products, and the research on the impact of government environmental protection R&D subsidies on investment in green innovation has started. Hamberg (1966) found that government research and development subsidies are conducive to promoting the R&D expenditure of enterprises by conducting research on enterprises receiving subsidies from the United States Department of Defense; Levy and Terleckyj (1983) examined the impact of different government R&D expenditures on private R&D expenditures and private sector productivity, and found that government subsidies have an impact on R&D investment lagging three years; However, Wallsten (2000) found through his research that the government subsidies for innovation projects received by small and medium-sized enterprises in the United States reduced their enthusiasm for R&D investment. Guellec and van Pottelsberghe (2003) first found an "inverted U-shaped" relationship between the two, that is, at the beginning, with the increase of the government subsidies rate, enterprises' R&D input gradually increases, but if the government subsidies continues to increase after a certain ratio, enterprises' R&D input will decrease, resulting in a crowding out effect. It can be seen that the conclusions of the academic research on the correlation between government environmental R&D subsidies and enterprises' green innovation investment are not uniform. Although some studies have found that environmental protection subsidies have a negative impact on enterprises' green innovation ability, or have a "crowding out" effect over a certain period of time, most scholars believe that government environmental R&D subsidies can encourage enterprises to enhance their awareness of green development and thus promote enterprises' green innovation investment.

In a few existing literatures on the intermediary role of green innovation investment, the positive effect of green innovation investment between government subsidies and financial performance has been verified. Zhang (2020) empirically analyzed the relevant data of 1198 listed companies in China from 2012 to 2017, and found that government subsidies can significantly improve enterprise performance with the help of technological innovation as part of the media; Zheng (2020) took rare earth enterprises as the research object, and found that under the full intermediary effect of technology R&D investment, government subsidies have a positive impact on the performance of enterprises in the back-end of the rare earth industry chain, and under the adjustment of organizational capital, technology R&D investment has a more significant positive effect on enterprise performance.

Through combing the existing literature, it is found that the research on the correlation between government subsidies and enterprise performance is relatively sufficient, but the research on the intermediary role of green innovation investment is less, and the measurement system of green innovation investment and enterprise financial performance is not unified. Therefore, this paper focuses on the mediating effect of green innovation investment, takes into account the government's environmental protection R&D behavior and enterprise's green innovation behavior, and makes a more targeted theoretical analysis and empirical test between the government's environmental R&D subsidies, green innovation investment and enterprise's financial performance according to the characteristics of electric power enterprises. In addition, the selection of the indicators that meet the research theme of this article and can accurately measure the level of real performance of the enterprise, improve the

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evaluation system of green innovations investments, so as to provide relevant supplement to the theory study of green innovation investment.

3. Theoretical Analysis and Research Assumptions

3.1. Government Environmental R&D Subsidies and Corporate Financial Performance

The general view of the research on the relationship between the two is that the government environmental R&D subsidies has a positive impact on the financial performance of enterprises. The "Porter Hypothesis" put forward by the famous scholar Porter (1991) believes that proper environmental regulation will encourage enterprises to engage in innovative activities, adopt more advanced technologies to reduce environmental costs, and improve enterprise business performance and market competitiveness; Domestic scholars Cao and Yi (2018) took listed companies in China's biomedical manufacturing industry from 2012 to 2015 as samples to verify that the continuity of government subsidies has a positive moderating effect on R&D investment and enterprise performance. Rong and Zhong (2020) found that government subsidies can positively affect enterprise performance through R&D investment of enterprises, and the effect is more obvious after one period.

According to the theory of information asymmetry, enterprises may not disclose their own green innovation activities completely and lag behind, which is easy to cause information asymmetry between investors and investees in the market. It is difficult for enterprises to find the financial support and talent support needed in the process of environmental research, development and production from the outside in time, which reduces the efficiency of enterprise innovation activities. In this context, the government's strengthening of subsidies for enterprises in environmental research and development can convey to the market the policy information of increasing national support for environmental research and development, release the positive signal that enterprises have good innovation ability, provide an implicit guarantee for enterprises' green innovation ability, attract potential investors, and guide the flow of social resources to enterprises with advantages in green innovation. It will help enterprises form a stable and diversified fund support chain for environmental research and development, relieve the pressure of funds in the process of research and development, and improve performance. In the case of asymmetric information, government subsidies in the field of environmental protection research and development can help enterprises obtain more financing opportunities and promote the improvement of financial performance. Therefore, this paper proposes hypothesis 1:

H1: Government environmental R&D subsidies have a positive effect on corporate financial performance.

3.2. Government Environmental R&D Subsidies and Green Innovation Investment

In general, under increasingly strict environmental regulations, government environmental R&D subsidies can give enterprises a signal to carry out green innovation activities through political means, and eliminate the risks brought by externalities to a certain extent. Therefore, government environmental R&D subsidies can stimulate enterprises' enthusiasm for green innovation, and have an obvious positive role in promoting enterprises' green innovation investment. Kleer (2010) argued that government subsidies can be used as a signal for private investors to make good investments by constructing a categorical subsidies signaling model; Domestic scholars Li and Yu (2016) took the companies listed in the heavy polluting industries from 2007 to 2014 as the research object to verify the impact of different government environmental policies on enterprise technological innovation, concluding that the

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government's environmental protection subsidies for enterprises are conducive to promoting the technological innovation of enterprises and are more evident in the eastern region; Shen and Zou (2018), using the endogenous transformation regression model under the counterfactual framework, found that China's R&D subsidies policy has an incentive effect on enterprises' R&D investment.

According to the signal transmission theory, increasing government subsidies for environmental R&D can not only guide investment and promote the financial performance of enterprises, but also convey positive information about the development of national key green industries, and release potential market demand signals for environmental R&D projects, which can enhance enterprises' environmental awareness and confidence in carrying out green research and development, encourage enterprises to carry out independent innovation activities, restrain market failures, and increase the impetus of green innovation investment to capture more market share. On the other hand, in view of the positive externality of environmental R&D, the high cost and high risk characteristics of environmental innovation projects make the uncertainty of enterprises' returns, while government's environmental R&D subsidies provide financial guarantee for enterprises' green innovation behaviors, which to a certain extent disperses the risks associated with the R&D activities conducted by enterprises, increases their willingness to conduct independent innovation, and motivates them to increase their green innovation investment. Thus, hypothesis 2 of this paper is proposed:

H2: Government environmental R&D subsidies have a positive promotion effect on enterprises' green innovation investment.

3.3. The Intermediary Role of Green Innovation Investment

With the green development concept gradually gaining popularity, domestic and international research on the correlation between green innovation investment and corporate financial performance began to emerge, and although the research is still in its infancy, it is argued through different research methods that innovation R&D investment, as a medium, plays a positive promoting role to a certain extent. Based on the Cobb-Douglas production function, Hu (2014) built a fixed-effect model and found that government subsidies could improve enterprise performance by expanding internal R&D investment and play a positive regulating and promoting role. Chen (2018) selected China's 2007-2015 manufacturing listed company data, adopted Homamoto's two-stage law, through empirical research discovered that environmental regulations can affect enterprise environmental research and development investment; Xu and Wang (2019), taking the new energy automobile industry as the research object, used the random effect model to conduct the Hausman test, and found that government subsidies improved the financial performance of new energy automobile enterprises, and R&D investment played a part of intermediary role in the process of government subsidies affecting financial performance.

According to the theory of sustainable development, in the long run, enterprises' green innovation investment can improve the efficiency of R&D operation and innovation output, provide power and support for the long-term development of enterprises. At the same time, it can help improve the social recognition of enterprises, establish a good image of green environmental protection, promote enterprises to obtain excess income, occupy more market share, and promote the growth of financial performance. In addition, according to the externality theory, for the negative externalities caused by environmental pollution formed in the daily production and life of electric power enterprises, the government's grant of environmental protection research and development subsidies can guide enterprises to invest in green innovation, correct the adverse effects of negative externalities, encourage enterprises to increase green output, and improve performance. As the investment of enterprises in technology innovation, such as funds and talents, the green innovation investment of

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enterprises plays a conductive role in the mechanism of the government's environmental protection R&D subsidies on the financial performance of enterprises, which to a certain extent determines the efficiency of the government's environmental protection R&D subsidies into the financial performance of enterprises. Reasonable R&D investment and sufficient high-quality R&D talents are strong guarantees to improve enterprise financial performance, so the green innovation investment plays an intermediary role in the process of government environmental protection R&D subsidies affecting enterprise financial performance. According to the existing literature and mechanism analysis, this paper holds that enterprises can improve their financial performance by investing funds and personnel in green innovation activities with the support of government environmental R&D subsidies. Based on the above analysis, this paper puts forward hypothesis 3:

H3: Green innovation investment plays an intermediary role between government environmental R&D subsidies and corporate financial performance.

4. Research Design

4.1. Research Samples

According to the industry classification results of the latest edition of CSRC, this paper selects the representative listed companies in electric power, thermal production and supply industries as the initial samples, sorts out their data from 2015 to 2021, excludes the listed companies whose main variable data are missing or unable to obtain data, excludes abnormal ST and *ST individuals, and selects 46 enterprises as the final research samples by screening and sorting out the data. All the data in the study were derived from the CSMAR Database and the RESSET Database. This paper uses the statistical software Stata15.0 for descriptive statistics, relevance analysis, regression analysis and robustness test.

4.2. Variable Definition and Measurement

According to the above mechanism analysis, research assumptions and model construction needs, this paper selects the following indicators for empirical analysis.

4.2.1. Explained Variable

This paper chooses per capita economic value added(EVA) as an indicator to measure corporate financial performance. Compared with the traditional single financial indicator, EVA takes into account all capital costs that bring corporate profits, emphasizes the link between shareholders' wealth and corporate decisions, and is more conducive to understanding the true value creation ability of a company. Previous literature usually uses the total economic value added indicator, but considering the differences in the number of employees, the per capita indicator is more representative of the average level of economic increment, so this paper chooses the per capita economic value added, which is the ratio of total economic value added to the number of employees of the enterprise, to measure the explanatory variable. The basic formula for calculating economic value added is net operating profit after tax - total capital * weighted average cost of capital, and the calculation caliber is generally divided into two kinds: SASAC caliber and CSMAR database caliber. In view of the latter's more comprehensive and scientific consideration of the adjustment of asset impairment items, this paper selects the economic value added per capita based on CSMAR database caliber as the measure, of which the specific calculation formula for each indicator is as follows:

Net operating profit after tax = operating profit-income tax expense+interest expense+impairment loss on assets+development expense+increase in deferred income tax liabilities-increase in deferred income tax assets.

Total capital = total owner's equity+asset impairment allowance-impairment allowance for construction in progress-net construction in progress+deferred income tax liabilities-deferred

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income tax assets+short-term borrowings+transactional financial liabilities+non-current liabilities due within one year+long-term borrowings+bonds payable+long-term payables.

Weighted average cost of capital = cost of bond capital x (1-income tax rate) * (debt capital/total capital)+cost of equity capital x (cost of equity/total capital) (Zheng K 2018).

4.2.2. Explanatory Variable

As the explanatory variable of this study, the government's environmental R&D subsidies (Ensubsidies) is mainly composed of the government's advance grant for research and development of environmental protection-related technology and equipment, such as low carbon and energy conservation, greening and cleaning, and ecological protection. Due to the lack of a unified disclosure system, in order to obtain a specific sample of government environmental R&D subsidies, this paper uses the keyword search method adopted by Guo (2018) to sort out the data. The government's subsidy for environmental protection research and development of power enterprises is mainly based on advance financial funds allocation. After receiving the subsidy funds, enterprises directly use them for research and development activities. Therefore, the data comes from the "government subsidies" subject in the notes to the financial statements of electric power enterprises in the 2015-2021 annual report in CSMAR database. According to the details of the projects, data containing keywords such as " Innovation " , " Science and technology " , " Technological transformation " , " Scientific research and development " , and " Research and development " are selected as the accounting content of government R&D subsidies, and then the data irrelevant to energy conservation and environmental protection, pollution prevention, desulfurization and dust removal, green ecological cleaning, consumption reduction and emission reduction, slag removal and dust removal, energy generation, low carbon and low nitrogen, garbage treatment, sewage discharge, circular economy and other projects are manually removed. Finally, the government environmental protection research and development subsidies are summarized according to the enterprise and accounting year, and the results are expressed as natural logarithms.

4.2.3. Intermediary Variable

As the intermediary variable of this paper, enterprise green innovation investment (GRD) has no unified evaluation system in China at present. Jiang et al. (2018) believed that green innovation investment can be measured by the proportion of R&D personnel, the ratio of green R&D funds, the profit rate of green product sales, and the market share of green products; Zhang et al. (2023) used R&D funding intensity, new product development funding intensity, the proportion of scientific researchers with master's degree or above in R&D institutions, full-time equivalent of R&D personnel, personnel input intensity, R&D intensity of science and technology institutions, R&D activity intensity, and R&D internal instrument and equipment acquisition cost (million yuan) to measure, synthesizing domestic and foreign scholars' research on the results of green innovation input measurement methods, most existing literature only uses a single indicator of R&D input as the standard, while this paper considers that in addition to the objective input amount of environmental R&D input amount, the influence of the number of R&D personnel should also be included, so this paper chooses to use the logarithm of the number of R&D personnel and environmental R&D input amount to measure the green innovation input of enterprises, and separately study the mediating role of each between government environmental R&D subsidies and firms' financial performance. Referring to the research of Liu (2019), environmental protection R&D investment mainly consists of projects related to environmental protection technology development in enterprise R&D investment. Based on the current "double carbon" strategy, most innovative R&D activities of electric power enterprises are related to energy conservation and environmental protection. Therefore, this paper selects the total R&D investment after excluding projects that are obviously unrelated to environmental protection to measure enterprise environmental

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protection R&D investment (GRD1). In addition, R&D personnel (GRD2), as the core element of R&D activities, greatly affects the effect of the transformation of government environmental protection R&D subsidies into enterprise financial performance improvement. Therefore, enterprise R&D personnel are selected as another indicator to measure enterprise green innovation investment, and the above data are expressed as natural logarithms.

4.2.4. Control Variable

In studying the influence of government environmental R&D subsidies and green innovation investment on the financial performance of enterprises, in order to prevent other factors from interfering, according to existing studies, this paper sets six control variables: (1) equity concentration (OwnCon1): the shareholding ratio of the first largest shareholder, shareholding ratio = number of shares held/total number of shares of the company; (2) Independent director ratio (Indpt_brd): number of independent directors/size of directors; (3) Equity ratio (Dbequrt): total liabilities/shareholders' equity, used to measure the solvency of enterprises; (4) Net operating profit rate (NprTOR): net profit/total operating income, to evaluate the profitability of enterprises; (5) Operating revenue growth rate (Opeincmgrt): operating revenue growth/total operating revenue of the previous year, used to evaluate the growth status and development capacity of enterprises; (6) Inventory turnover rate (Invttrrat): main business cost/average inventory, average inventory=(opening inventory+closing inventory)/2, which measures the sales ability of enterprises. The above data are from RESSET database.

4.3. Model Construction

In order to verify the hypothesis proposed above, this paper uses the causal stepwise regression method to test the intermediary effect. At the same time, in order to control the interference caused by time change, the fixed year effect is added, and the following multiple regression model is constructed:

Based on hypothesis 1, this paper examines the effect of government environmental R&D subsidies on the financial performance of enterprises with explanatory variables:

$$EVA_{i,t} = \alpha_0 + \alpha_1 Ensubsidy_{i,t} + \alpha_2 OwnCon1_{i,t} + \alpha_3\ Indpt\_brd_{i,t} + \alpha_4 Dbequrt_{i,t} + \alpha_5 NprTOR_{i,t} + \alpha_6 Opeincmgrrt_{i,t} + \alpha_7 Invtrtrrat_{i,t} + \varepsilon_{i,t} \quad (1)$$

According to hypothesis 2, the influence of the intermediary variable enterprise green innovation investment on the per capita economic value added of the explained variable is investigated. This paper uses the logarithm of the amount of environmental R&D investment and the number of R&D personnel to measure the enterprise green innovation investment. Therefore, two models are set up to test the impact of the two on the per capita economic value added, and models 2 and 3 are set:

$$GRD1_{i,t} = \beta_0 + \beta_1 Ensubsidy_{i,t} + \beta_2 OwnCon1_{i,t} + \beta_3\ Indpt\_brd_{i,t} + \beta_4 Dbequrt_{i,t} + \beta_5 NprTOR_{i,t} + \beta_6 Opeincmgrrt_{i,t} + \beta_7 Invtrtrrat_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$GRD2_{i,t} = \gamma_0 + \gamma_1 Ensubsidy_{i,t} + \gamma_2 OwnCon1_{i,t} + \gamma_3\ Indpt\_brd_{i,t} + \gamma_4 Dbequrt_{i,t} + \gamma_5 NprTOR_{i,t} + \gamma_6 Opeincmgrrt_{i,t} + \gamma_7 Invtrtrrat_{i,t} + \varepsilon_{i,t} \quad (3)$$

According to hypothesis 3, the role of the intermediary variable enterprise green innovation investment in the process of the explanatory variable government environmental R&D subsidies affecting the per capita economic value added of the explained variable is investigated,

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and two models are constructed to verify the intermediary effect of the amount of environmental R&D investment and the number of R&D personnel, and models 4 and 5 are set:

$$EVA_{i,t} = \rho_0 + \rho_1 Ensubsidy_{i,t} + \rho_2 GRD1_{i,t} + \rho_3 OwnCon1_{i,t} + \rho_4\ Indpt\_brd_{i,t} + \rho_5 Dbequrt_{i,t} + \rho_6 NprTOR_{i,t} + \rho_7 Opeincmgrrt_{i,t} + \rho_8 Invtrtrrat_{i,t} + \theta_t + \varepsilon_{i,t} \quad (4)$$

$$EVA_{i,t} = \sigma_0 + \sigma_1 Ensubsidy_{i,t} + \sigma_2 GRD2_{i,t} + \sigma_3 OwnCon1_{i,t} + \sigma_4\ Indpt\_brd_{i,t} + \sigma_5 Dbequrt_{i,t} + \sigma_6 NprTOR_{i,t} + \sigma_7 Opeincmgrrt_{i,t} + \sigma_8 Invtrtrrat_{i,t} + \theta_t + \varepsilon_{i,t} \quad (5)$$

In the above models, i is the firm, t is the year, $\alpha_0, \beta_0, \gamma_0, \rho_0, \sigma_0$ are the constant, $\alpha_i, \beta_i, \gamma_i, \rho_i, \sigma_i$ are the regression coefficient, θ_t is the time fixed effect, and $\varepsilon_{i,t}$ is the random error.

There are three steps to test the intermediary effect: the first step is to regress the model 1 and test the significance. The regression coefficient represents the total effect of government environmental R&D subsidies on the financial performance of enterprises. If it is significantly positive, then suppose 1 is true and proceed to the next step; The second step is to test the significance of β_1 and γ_1 by regressing models 2 and 3 respectively. β_1 represents the effect of government environmental protection R&D subsidies on environmental R&D investment, and γ_1 represents the effect of government environmental R&D subsidies on the number of R&D personnel. If both are significantly positive, then assumption 2 is valid; In the third step, regressions of models 4 and 5 are performed respectively, and the regression coefficients ρ_2 and σ_2 indicate the direct effect of government environmental R&D subsidies on firms' financial performance after controlling for green innovation investment. If both are significantly positive, further test the significance of ρ_1 and σ_1 . ρ_1 and σ_1 represent the effect of green innovation investment on firm's financial performance after controlling for government environmental R&D subsidies, and $\beta_1 * \rho_2$ and $\beta_1 * \sigma_2$ represent the indirect effect of government environmental R&D subsidies on firm's financial performance. If ρ_1 and σ_1 are also significantly positive and satisfy $\rho_1 < \alpha_1, \sigma_1 < \alpha_1$, then hypothesis 3 is true, and green innovation investment plays a part of intermediary role; If ρ_1 and σ_1 are not significant, then green innovation investment plays a full intermediary role.

5. Empirical Results and Analysis

5.1. Descriptive Statistic

Table 1. Descriptive statistics of variables

Variables	Number	mean	sd	min	max
Ensubsidy	235	13.92	1.484	7.241	17.10
EVA	235	1.952	9.471	-26.30	58.92
GRD1	235	17.08	1.852	11.58	21.84
GRD2	235	4.656	1.620	0.693	8.483
OwnCon1	235	0.415	0.156	0.108	0.728
Indpt_brd	235	32.45	7.469	14.29	55.56
NprTOR	235	17.24	56.47	-147.2	417.5
Dbequrt	235	235.0	521.3	6.085	6,893
Opeincmgrt	235	7.018	18.31	-65.97	81.09
Invttrrat	235	23.11	39.05	0.345	367.3

Through the descriptive analysis of the main variables of the selected samples, it can be seen from Table 1 that the average value of government environmental R&D subsidies (Ensubsidy) is 13.92, indicating that the sample enterprises have a high intensity of accepting government environmental R&D subsidies; The minimum and maximum values of economic value added

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per capita (EVA) are -26.30 and 58.92 respectively, indicating that the financial performance of enterprises varies greatly with the operation mode and year; The average value of green innovation investment (GRD1) after the exclusion of enterprises with no obvious relationship to environmental protection is 17.08, and the standard difference in the number of R&D personnel (GRD2) is 1.620, which indicates that the sample enterprises generally pay more attention to the environmental R&D investments, and the R&D personnel are distributed evenly.

5.2. Correlation Analysis

In this paper, Pearson correlation analysis is carried out for the sample enterprises, and the specific results are shown in Table 2. It can be seen from the table that the main variable government environmental R&D subsidies (Ensubsidy) has a positive correlation with per capita economic value added (EVA) at a significant level of 5%, which indicates that the explanatory variable government environmental R&D subsidies has a significant positive impact on the financial performance of the explained variable enterprises, which preliminarily verifies hypothesis 1; At a significant level of 1%, the government environmental R&D subsidies (Ensubsidy) has a positive correlation with the amount of research and development investment (GRD1) and the number of research and development personnel (GRD2) that have no significant relationship with environmental protection, indicating that the government environmental R&D subsidies has a significant positive impact on the intermediary variable enterprise green innovation investment (GRD), which preliminarily shows that hypothesis 2 is tenable.

Table 2. Variable correlation analysis

Variables	Ensubsidy	EVA	GRD1	GRD2	OwnCon1	Indpt_brd	NprTOR	Dbequrt	Ope	Inv
Ensubsidy	1									
EVA	0.158**	1								
GRD1	0.293***	0.146**	1							
GRD2	0.297***	0.0980	0.749***	1						
OwnCon1	0.312***	0.263***	0.258***	0.211***	1					
Indpt_brd	-0.0310	-0.154**	0.0740	0.0760	-0.0710	1				
NprTOR	0.0140	0.594***	0.00300	-0.0280	0.183***	-0.0520	1			
Dbequrt	-0.117*	-0.0870	-0.0200	-0.0630	-0.00200	-0.130**	-0.133**	1		
Ope	0.176***	0.0480	0.156**	0.0780	0.131**	0.0890	0.0460	-0.0130	1	
Inv	0.00600	0.281***	0.0840	-0.0990	0.133**	-0.0150	-0.00200	-0.0150	0.0850	1

5.3. Regressivity Analysis

Table 3 reflects the regression analysis results of all hypothetical models. From the data of model (1) in the table, it can be seen that the regression coefficient between government environmental R&D subsidies (Ensubsidy) and per capita economic added value (EVA) is 0.88768, which is significant at the level of 5%, indicating that there is a significant positive correlation between government environmental R&D subsidies and the financial performance level of electric power enterprises. That is, an increase of government environmental R&D subsidies drives the financial performance of enterprises to improve by 0.88768 units, which shows that hypothesis 1 is established. Government environmental R&D subsidies can effectively enhance the enthusiasm of enterprises to invest in research and innovation, and to a certain extent, drive the performance level of enterprises.

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Table 3. Variable regression analysis

Model	(1)	(2)	(3)	(4)	(5)
Variables	EVA	GRD1	GRD2	EVA	EVA
Ensubsidy	0.88768**	0.27307***	0.28305***	0.71588**	0.69226**
	(0.01026)	(0.00142)	(0.00025)	(0.04051)	(0.04923)
GRD1				0.62917**	
				(0.02078)	
GRD2					0.69040**
					(0.02248)
OwnCon1	4.74133	2.06904***	1.70163**	3.43956	3.56652
	(0.13724)	(0.00887)	(0.01662)	(0.28311)	(0.26471)
Indpt_brd	-0.12966**	0.01870	0.01858	-0.14142**	-0.14249**
	(0.03925)	(0.22640)	(0.18160)	(0.02375)	(0.02286)
NprTOR	0.09597***	-0.00026	-0.00163	0.09613***	0.09710***
	(0.00000)	(0.90183)	(0.38546)	(0.00000)	(0.00000)
Dbequrt	0.00012	-0.00003	-0.00010	0.00013	0.00019
	(0.89812)	(0.89309)	(0.60909)	(0.88049)	(0.83506)
Opeincmgrrt	-0.01964	0.00676	0.00083	-0.02389	-0.02021
	(0.48449)	(0.32892)	(0.89340)	(0.39146)	(0.46754)
Invtrtrrat	0.06525***	0.00238	-0.00486*	0.06375***	0.06860***
	(0.00000)	(0.41686)	(0.06675)	(0.00000)	(0.00000)
_cons	-11.28970**	11.43080***	-0.52915	-18.48156***	-10.92437**
	(0.04167)	(0.00000)	(0.66549)	(0.00355)	(0.04666)
N	235	235	235	235	235
adj. R^2	0.4595	0.1408	0.0916	0.4701	0.4698

The models (2) and (3) in the table respectively verify the relationship between government environmental R&D subsidies and R&D investment (GRD1) excluding data unrelated to environmental protection, and between government environmental R&D subsidies and the number of R&D personnel (GRD2). The data shows that the government environmental R&D subsidies and these two indicators are significant at the level of 1%, with a regression coefficient of 0.27307 for R&D investment and 0.28305 for R&D personnel, indicating that the government's enhanced environmental R&D subsidies can positively promote the increase of green innovation investment of enterprises, and hypothesis 2 is verified. This further indicates that China's environmental R&D subsidy policy plays a significant role in targeted solutions to environmental R&D issues in enterprises. Strengthening government subsidies in this field can help power enterprises widely carry out green innovation activities.

Models (4) and (5) are used to test the intermediary role of green innovation investment. The empirical results show that after adding the R&D investment excluding the data unrelated to environmental protection, the government's environmental R&D subsidies and the financial performance of enterprises are still significant at the level of 5%, with a regression coefficient of 0.71588, and the R&D investment is significant at the level of 5%, with a regression coefficient of 0.62917, indicating that the green innovation investment has played a part of the intermediary effect, and this intermediary effect is 0.1718, accounting for 19.35% of the total effect; After adding the intermediary variable R&D personnel, the regression coefficient between government environmental R&D subsidies and enterprise financial performance is 0.69226, which is significant at the level of 5%, indicating that the number of R&D personnel also plays a part of the intermediary effect, and the intermediary effect of R&D personnel is 0.1954, accounting for 22.01% of the total effect. On the whole, green innovation investment plays a significant part of the intermediary role between government environmental R&D subsidies and enterprise financial performance, that is, green innovation investment promotes the positive impact of government environmental R&D subsidies on enterprise financial

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performance, and environmental protection R&D investment and the number of R&D personnel belong to parallel intermediaries, which do not affect each other and play an intermediary role independently. Hypothesis 3 is established.

5.4. Robustness Test

In order to better test the true reliability of the above empirical results, this paper adopts the method of replacing the explanatory variables for robustness testing, replaces the logarithm of government environmental R&D subsidies amount with government environmental R&D subsidies intensity (SUB), and re-runs the regression analysis of the above hypothetical model, drawing on the study of Wang et al. (2022) and selects the ratio of government environmental R&D subsidies amount to electricity operating revenue to measure the intensity of government environmental R&D subsidies. As can be seen from Tables 4, the robustness test results remain consistent with the results of the multiple regression analysis, and the hypotheses are again validated, further supporting the empirical findings.

Table 4. Robustness test results

Model	(1)	(2)	(3)	(4)	(5)
Variables	EVA	GRD1	GRD2	EVA	EVA
SUB	0.23636**	0.06503***	0.06529***	0.19437**	0.18979**
	(0.01272)	(0.00574)	(0.00217)	(0.04135)	(0.04723)
GRD1				0.64573**	
				(0.01706)	
GRD2					0.71333**
					(0.01737)
OwnCon1	5.73792*	2.42523***	2.08452***	4.17189	4.25096
	(0.06453)	(0.00174)	(0.00284)	(0.18318)	(0.17421)
Indpt_brd	-0.15619**	0.01112	0.01089	-0.16337***	-0.16396***
	(0.01377)	(0.47611)	(0.43949)	(0.00935)	(0.00912)
NprTOR	0.08960***	-0.00208	-0.00348*	0.09094***	0.09208***
	(0.00000)	(0.32992)	(0.07145)	(0.00000)	(0.00000)
Dbequrt	0.00026	-0.00000	-0.00008	0.00026	0.00032
	(0.77546)	(0.99966)	(0.71143)	(0.77306)	(0.72798)
Opeincmgrrt	-0.00883	0.01024	0.00448	-0.01544	-0.01202
	(0.74833)	(0.13406)	(0.46700)	(0.57268)	(0.65920)
Invtrtrrat	0.06667***	0.00271	-0.00454*	0.06492***	0.06991***
	(0.00000)	(0.36023)	(0.09035)	(0.00000)	(0.00000)
_cons	-3.63800	13.92105***	2.08977***	-12.62718**	-5.12871
	(0.29922)	(0.00000)	(0.00808)	(0.01394)	(0.14594)
N	235	235	235	235	235
adj. R^2	0.4586	0.1308	0.0750	0.4700	0.4700

6. Conclusion and Suggestions

6.1. Conclusion

Under the strategic background of "double carbon", green development has become a major issue for enterprises, and how to realize the dual environmental protection research and development path of government and enterprise has become an important issue at present. Based on this, 46 typical listed electric power enterprises from 2015 to 2021 are selected as research samples in this paper. The hypothesis model is verified by multiple regression analysis, and the following conclusions are drawn: First, government subsidies for environmental R&D of electric power enterprises have a direct role in promoting their financial performance. That is to say, government subsidies for environmental R&D can promote investment, facilitate

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enterprises to obtain adequate funds for environmental R&D, promote enterprises to achieve more R&D results and improve their performance. Second, government subsidies for environmental R&D enhance the awareness of green innovation of enterprise managers, so that enterprises realize the importance of improving the investment of environmental protection research and development personnel, and have a significant positive impact on enterprises' green innovation investment. Thirdly, enterprise green innovation investment plays an intermediary role between government environmental R&D subsidies and financial performance, which can effectively transform government environmental R&D subsidies into enterprise performance improvement. That is, through increasing enterprise green innovation investment, government environmental R&D subsidies can indirectly promote financial performance.

6.2. Suggestions

6.2.1. From the Perspective of the Government

Relevant government departments should increase subsidies in the field of environmental R&D and expand subsidies channels. The government should allocate the subsidies funds for environmental protection R&D more pertinently and tendentiously, improve the subsidies policy, and comprehensively use various subsidies means such as financial supplement, financial discount, tax refund, etc., so as to realize the effective combination of government environmental protection assistance and enterprise R&D support, drive the enthusiasm of enterprises to invest in green innovation, and promote the improvement of enterprise financial performance.

6.2.2. From the Perspective of Enterprise

Electric power enterprises should cultivate the consciousness of innovation and improve the ability of green innovation. As the main body of green innovation, electric power enterprises should actively fulfill their social responsibilities of energy conservation and environmental protection, formulate a systematic green innovation system, and make full use of environmental R&D subsidies issued by the government. On the one hand, increase the amount of R&D investment on environmental protection projects to provide material protection and own support for enterprises' green innovation activities; On the other hand, introduce a more professional and stable environmental protection R&D team, regularly conduct special training in environmental protection technology R&D, provide technical and talent support, pursue the maximum efficiency of the use of government environmental R&D subsidies, and improve the financial performance of enterprises.

References

[1] Braun E, Wield D (1994) Regulation as a means for the social control of technology. Technol Anal Strateg Manag 6:259-272. https://doi.org/10.1080/09537329408524171.

[2] Cao Y, Yi Q-Q (2018) The impact of government subsidies on R&D investment and performance of enterprises: an empirical study based on biomedical manufacturing. Science and Technology Management Research 1:40-46.

[3] Chen Y-K (2018) Revalidation of Strong Porter Hypothesis under fiscal decentralization -- from the perspective of corporate environmental innovation and non-environmental innovation. Business Research 1:143-152. https://doi:10.13902/j.cnki.syyj.2018.01.017.

[4] Guellec D, van Pottelsberghe B (2003) The impact of public R&D expenditure on business R&D. Econ Innov New Technol 12:225-243. https://doi.org/10.1080/10438590290004555.

[5] Guo Y (2018) Signal transmission mechanism of government innovation subsidies and enterprise innovation. China Industrial Economy 9:98-116. https://doi:10.19581/j.cnki.ciejournal. 2018.09. 016.

ISSN: 2692-7608 DOI: 10.6981/FEM.202308_4(8).0051

[6] Hamberg D (1966) R & D: essays on the economics of research and development. Random House, New York, NY.

[7] Hu Y-P (2014) Government subsidies, technology sources and Innovation Performance: An Empirical study based on large and medium-sized industrial enterprises in Chongqing. Technical Economics and Management Research 7:46-50.

[8] Jenkins JC, Leicht KT, Jaynes A (2006) Do high technology policies work? High technology industry employment growth in U.S. metropolitan areas, 1988-1998. Soc Forces 85:267-296. https://doi.org/10.1353/sof.2006.0128.

[9] Jiang Y-H, Luo Y-M, Yun R-L (2018) Research on the correlation between green innovation input and financial performance of Automobile manufacturing enterprises. Accounting and Finance 1:15-22.

[10] Jin Z, Shang Y, Xu J (2018) The impact of government subsidies on private R&D and firm performance: does ownership matter in China's manufacturing industry? Sustainability 10:2205. https://doi.org/10.3390/su10072205.

[11] Kleer R (2010) Government R&D subsidies as a signal for private investors. Res Policy 39:1361-1374. https://doi.org/10.1016/j.respol.2010.08.001.

[12] Levy DM, Terleckyj NE (1983) Effects of government R&D on private R&D investment and productivity: a macroeconomic analysis. Bell J Econ 14:551-561. https://doi.org/10.2307/3003656.

[13] Li N, Yu J (2016) The impact of government environmental policy on enterprise technological innovation. World Science and Technology Research and Development 5:932-936+954. https://doi:10.16507/j.issn.1006-6055.2016.05.002.

[14] Liu X (2019) Research on government environmental subsidies, environmental R&D Investment and enterprise environmental performance, Anhui University. https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201902&filename=1019142628.nh.

[15] Pigou AC (1920) The economics of welfare. Macmillan, London.

[16] Porter ME (1991) America's green strategy. Sci Am 264:168. https://doi.org/10.1038/scientificamerican0491-168.

[17] Rong F-Z, Zhong X-J (2020) An empirical test of the correlation between government subsidies, R&D investment and firm performance. Statistics and Decision 5:161-165. https://doi:10.13546/ j.cnki.tjyjc.2020.05.036.

[18] Shen P-Y, Zou H-F (2018) Government R&D subsidies and enterprise R&D input: A Case study of Listed manufacturing companies in China. Shanghai Economic Research 8:84-93. https://doi:10.19626/j.cnki.cn31-1163/f.2018.08.010.

[19] Wallsten SJ (2000) The effects of government-industry R&D programs on private R&D: the case of the small business innovation research program. RAND J Econ 31:82-100. https://doi.org/ 10.2307/2601030.

[20] Wang Z-C, Wang Y (2022) Research on the effect of government subsidy on the performance and R&D Investment of Medical Device Manufacturing Enterprises. China's collective economy 17:102-105.

[21] Xu H, Wang L (2019) Government subsidies, R&D investment and financial performance of new energy vehicles enterprises. Sci Innov 7:137. https://doi.org/10.11648/j.si.20190705.11.

[22] Zhang E-Z, Cui L-L, Wang C (2020) Government subsidies, technological innovation, and corporate performance: empirical evidence based on A-share listed companies. Journal of Shandong University of Finance and Economics 5:87-98.

[23] Zhang Y, Xue W-W, Wang X-J (2023) Evaluation of green technology innovation capability in Chinese manufacturing industry from the perspective of value chain: An empirical study based on cloud model. Ecological economy 1:74-80.

[24] Zheng M-G, Dong J, Zhong C-B (2020) The impact of government subsidies on the performance of rare earth enterprises in China. China Science and Technology Forum 10:93-103. https://doi:10.13580/j.cnki.fstc.2020.10.017.

ISSN: 2692-7608 DOI: 10.6981/FEM.202308_4(8).0051

[25] Zheng K (2018) Application and research of EVA in power generation enterprise. Business Accounting 20:50-52.