The Influence of Technological Innovation on ESG Performance in Electric Power Enterprises

——Empirical Study on A-share and H-share Listed Companies

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Abstract. Based on 451 listed A-share and H-share power companies from 2009 to 2023, this study empirically examines the impact of technology innovation investment in power companies on their ESG performance. The research results indicate that increasing investment in technological research and development by enterprises is beneficial for improving the ESG performance of power companies, but there are differences among power companies of different energy types. The investment in technological innovation by new energy power companies has a greater promoting effect on the company's ESG performance. Based on the research results, with the goal of improving the ESG performance of power companies of different energy types, this article proposes relevant suggestions for traditional energy power companies and new energy power companies to increase their investment in scientific and technological innovation.

Keywords: Technological innovation, ESG performance, New energy power enterprises

1 Introduction

Against the backdrop of increasing global awareness of sustainable development and environmental protection, the ESG (Environmental, Social, and Governance) performance of electric power companies has become a core issue of widespread concern for investors, regulatory bodies, and the public. Existing research generally holds that ESG strategy is a comprehensive reflection of a company's fulfillment of social responsibilities (Qi Yue et al., 2023)[1]. On one hand, companies are not just entities that pursue economic profits; they should also consider social and environmental factors in their business activities. On the other hand, this comprehensive consideration aims to help companies better adapt to changes, reduce risks, attract investments, and align

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with societal expectations for responsible business operations (Mao Qilin and Wang Yueqing, 2023)[2].

As for how technological innovation of power enterprises affects their ESG performance, from the environmental dimension, power enterprises can help reduce energy consumption and pollutant emission by increasing research and development investment in advanced carbon reduction technologies and equipment such as efficient combustion technology and waste heat recovery technology, thus helping power enterprises to improve ESG performance (Zhang Lin and Zhao Haitao,2019)[3]. From the social dimension, by increasing investment in scientific and technological innovation, power enterprises can help improve their ability to fulfill social responsibilities and improve the working environment of employees, thus indirectly affecting ESG performance(Pei Xuan et al.,2023)[4].In terms of governance, by increasing investment in technological innovation such as digitalization, power enterprises can accelerate the digital transformation and upgrading of enterprises, optimize the enterprise management mechanism and decision-making process, and indirectly improve ESG performance(Zong Z,2024)[4].

For the impact of technological innovation investment of different types of power enterprises on their ESG performance, clean energy power enterprises such as wind power and photovoltaic strengthen technological innovation, improve the conversion efficiency of wind power and photovoltaic equipment, promote the recycling and reuse of waste photovoltaic modules and wind turbine blades, in order to reduce energy consumption and carbon emissions, and improve the ESG performance is more obvious(Li et al.,2023)[4]. For traditional energy enterprises such as coal power, relying on scientific and technological innovation investment to accelerate energy conservation, emission reduction and waste emission treatment, but their carbon reduction development technology is difficult, slow investment effect and other problems may lead to relatively limited improvement in their ESG performance(Yang et al.,2024)[4].

In recent years, as a key carbon emission entity, electric power enterprises bear greater pressure in the process of reducing carbon emissions. As an important production factor to improve production efficiency and promote industrial upgrading, scientific and technological innovation is an important factor for different types of electric power enterprises to rely on scientific and technological innovation to improve ESG performance and its effects are still lacking systematic research results. At present, the ESG standard at home and abroad does not directly include scientific and technological innovation into the general core issues, but whether it is the solution of environmental pollution, climate change and other problems, or the improvement of product quality and governance efficiency, it is inseparable from the integration of scientific and technological innovation and enterprise management. Based on the above reasons, this paper selects 451 A-share and H-share listed companies of Chinese power enterprises from 2009 to 2023 to demonstrate the impact of technological innovation of power enterprises on ESG performance of enterprises, and provides suggestions for power enterprises to strengthen scientific and technological innovation, increase investment in research and development, promote the stable operation of the company and improve performance.

2 The Oretical Analysis and Research Hypotheses

ESG performance covers environmental protection, social responsibility and corporate governance. Environmental protection (E) mainly focuses on the impact of enterprises on the environment in the process of production and operation, including carbon emissions, waste management, energy utilization efficiency, natural resource consumption, etc. At present, the pressure of local environmental governance in China has played a significant role in promoting the r & d investment intensity of real enterprises (Zhang Jianping, Zhang Xu, 2024)[8]. Technological innovation directly affects the ESG performance of power companies by providing more efficient and environmentally friendly technology solutions and products, and by improving energy efficiency and promoting the application of clean energy. Social indicators (S) emphasize the social responsibilities of enterprises, such as employee safety and health, supply chain relationship, product safety and quality, community relationship, etc. Zhang Duolei and Yuan Li (2024) believe that the improvement of ESG level can narrow the income gap between senior executives and employees, thus promoting common prosperity within the enterprise[9]. Technological innovation can enhance corporate social responsibility and improve the working environment of employees to indirectly affect ESG performance. Governance index (G) involves the governance structure and management level of the enterprise, including the board of directors structure, executive compensation distribution, enterprise risk management, financial and ESG information disclosure, etc. The impact of technological innovation on corporate governance is manifold (Babak Naysary and Keshab Shrestha, 2024)[10], To indirectly improve ESG performance by optimizing enterprise management and decision-making process and promoting enterprise digital transformation.

To sum up, this paper assumes that increased investment in technological innovation will improve the ESG performance of enterprises.

3 Empirical Study Design

Considering the time lag effect, in order to evaluate the impact of technological innovation on the long-term effect of ESG performance, this paper uses dynamic panel data to study the impact of enterprise ESG performance and technological innovation investment in the last period. This paper sets the following regression model.

$$ESG_{i,t} = \beta_0 + \beta_1 \mathrm{lgRD}_{i,t-1} + \beta_2 Controls_{i,t-1} + \varepsilon_{i,t-1} \quad (1)$$

3.1 Index Selection

Interpreted variables, consistent with Xi Longsheng and Zhao Hui (2022)[11]、Xie Hongjun and Lyu Xue (2022)[12], we measure the ESG performance of enterprises based on the CSI ESG rating. We convert the ESG rating into numerical form: when the rating is the lowest C, the value is 1, and on this basis, the rating is 1 for each

increase. For example, CCC is 3, BBB is 6, and AAA is 9. On this basis, the average of four ESG times in a year is used to measure the ESG performance in the year[1].

In terms of explanatory variables, the R&D investment scale (lgR&d) and the R&D intensity (R&d intensity) are used to measure the scale of enterprise science and technology innovation investment (lgRD). In order to prevent the data difference from being too large, the scale of R&D investment is taken logarithmic, and the R&D intensity is expressed by the ratio of R&D investment to operating income.

In terms of control variables, consistent with most existing studies, this article has added the following control variables: (1) Enterprise size (SIZE), taking the logarithm of total assets; (2) Company Growth Index (GRO), (year-end total assets - beginning total assets)/beginning total assets; (3) Revenue Growth Rate (IRB); (4) The nature of equity (SOE) is taken as 1 for state-owned enterprises and 0 for others; (5) The province (province).The definitions and descriptions of each variable are shown in Table 1.

Table 1. Variable Definition

Variable name	Variable symbol	Variable Definition
Enterprise ESG performance	ESG	Huazhong ESG Rating Score
Scale of R&D investment	lgR&d	Logarithmic scale of R&D investment
R&D intensity	R&d intensity	Ratio of R&D investment to operating revenue
Company size	SIZE	Natural logarithm of the total assets
Company growth	GRO	(Total assets at the end of the year-total assets at the beginning of the year) / total assets at the beginning of the year
Revenue growth rate	IRB	(Operating income of current year-operating income of previous year) / operating income of previous year
Nature of stock rights	SOE	State-owned enterprises take 1, other take 0

3.2 Data Source and Sample Selection

This study takes China's A-share and H-share listed companies from 2009 to 2023 as the initial research samples, and the data comes from the Wind database. In the power

[1]China card ESG evaluation system is based on the public disclosure of listed companies, regular reports and temporary announcement, social responsibility of listed companies and sustainable development report, the government and relevant regulatory department website data, news media data, etc., in reference to the international mainstream ESG evaluation system and combined with the characteristics of our country market adjustment of ESG index system.

industry, there are 451 listed companies in three sub-industries, including power generation, grid and power equipment. In order to avoid the influence of data outliers on the regression results, all continuous variables are indentured at 1% and 99% of their distribution.

4 Analysis of the Empirical Results

4.1 Basic Regression Results Analysis

By screening and processing the sample variables of A-share and H-share listed companies in China, 422 observation values were ultimately obtained. Table 2 presents the descriptive statistical results of all variables, with a mean ESG performance of 6.47 and a standard deviation of 1.12 for the sample companies. The average R&D investment scale is 0.46, with a standard deviation of 0.14. The average R&D intensity is 2.35, with a standard deviation of 2.26.

Table 2. Descriptive Statistics

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
ESG	422	6.47	1.12	1.00	9.00
lgR&d	422	0.46	0.14	0.08	0.65
R&d intensity	422	2.35	2.26	1.01	75.91
SIZE	422	23.45	1.31	19.89	28.64
GRO	422	0.14	0.25	-0.30	1.41
IRB	422	0.16	0.38	-0.52	2.35
SOE	422	0.31	0.46	0.00	1.00

Table 3 shows the regression results of scientific and technological innovation investment on the ESG performance of electric power enterprises. However, the results show that the coefficient of R&D investment scale and enterprise ESG performance is significantly positive, while the coefficient of R&D intensity is not significant. This difference may be caused by the endogenous problem.

Table 3. The impact of scientific and technological innovation on the ESG performance of electric power enterprises

Variable	(1) ESG	(2) ESG
lgRD	0.30^{***} (0.09)	
R&d intensity		-0.24 (0.05)
SIZE	0.29^{***} (0.01)	0.286^{***} (0.01)

Variable	(1) ESG	(2) ESG
GRO	-0.01*** (0.00)	-0.01*** (0.00)
IRB	0.04* (0.02)	0.05** (0.02)
SOE	0.02*** (0.00)	0.02*** (0.00)
Observations	422	405

4.2 Instrumental Variable Regression

Considering the endogenous problem, this paper selects government incentive (GI) and tax preference (TI) as instrumental variables. The Wald test-test value of the exogenous null hypothesis indicates that it is significant at the 1% confidence level, and the F value of the two-stage estimation method is also significant, so the instrumental variable and the explained variable are exogenous, and the empirical test results show that no weak instrumental variable will be produced.

Table 4 shows the regression results after adding the tool variables. The coefficient of R&D investment and R&D intensity is significantly positive, indicating that the improvement of R&D investment and R&D intensity has a positive effect on the ESG performance of enterprises.

Table 4. Tool variable regression

Variable	(1) ESG	(2) ESG
lgRD	0.33*** (0.07)	
R&d intensity		0.17*** (0.07)
Observations	422	405
First-stage F	120.52***	219.65***
Wald test	16.13***	15.26***

4.3 Further Analysis

In order to further study whether the influence is different under the nature of different enterprises, this paper divides the listed enterprises according to different energy resources. If they belong to new energy power enterprises, nature=1; if it is a traditional energy power enterprise, nature=0, which is studied through group regression and cross entry (nature lgRD, nature R & d intensity). The results are shown in Table 5, the coefficient of nature lgRD in column (3) and nature R &d intensity in column (6) is significantly and positively correlated, indicating that compared with traditional

energy power enterprises, the higher the scientific and technological innovation investment of new energy power enterprises, the more it helps to improve their ESG performance.

Table 5. The impact of scientific and technological innovation on the ESG performance of traditional energy and new energy power enterprises

Variable	(1) New energy	(2) Traditional energy	(3) Full sample	(4) New energy	(5) Traditional energy	(6) Full sample
lgRD	0.48*** (0.08)	0.26*** (0.11)	0.34*** (0.08)			
R&d intensity				0.30*** (3.31)	0.15*** (2.01)	0.23*** (2.01)
nature×lgRD			0.36*** (0.13)			
nature×R&d intensity						0.57*** (3.92)
Observations	422	367	422	410	415	405
First-stage F	420.69***	151.42***	349.32***	552.11***	350.23***	160.57***
Wald test	68.49***	56.13***	19.56***	12.26***	40.18***	63.19***

5 Conclusions and Revelations

5.1 Conclusion

After in-depth empirical research, we found a significant positive correlation between the investment of power companies in technological innovation and their environmental, social, and governance (ESG) performance. Specifically, the more companies invest in technological innovation, the more significant the improvement in their ESG performance. However, this impact exhibits certain differences among different types of energy enterprises. The research results indicate that for power companies focused on new energy, the increase in investment in technological innovation has a particularly prominent positive impact on their ESG performance. This may be because the new energy sector itself has a high demand for innovation and technological progress, which enables more effective conversion of technological innovation investment into ESG performance improvement.

5.2 Revelation

Based on the empirical analysis of the impact of technological innovation on ESG (environmental, social, and governance) performance of power companies listed on

A-shares and H-shares in China, we can provide the following insights for power companies of different energy types to invest in technological innovation based on the differentiated characteristics of technological innovation:

For power companies that rely on traditional energy, they should actively seek development opportunities in the field of new energy while ensuring the stable development of traditional energy business. This includes transforming and upgrading traditional energy technologies, continuously promoting energy-saving, heating, and flexibility upgrades to further reduce the energy consumption level of coal-fired power units. In addition, these enterprises should also support the application of green and low-carbon materials, the development of new tower technologies, the promotion of land saving technologies, and the use of high-efficiency and intelligent wind turbines. Through these optimization techniques and measures to improve energy efficiency, environmental pollution and carbon emissions can be effectively reduced.

For new energy power enterprises, they need to continue to increase investment in technological innovation, especially in cutting-edge fields such as clean energy, energy storage technology, and smart grids for in-depth research and development. These efforts will help improve the efficiency and stability of clean energy generation, thereby providing more reliable and efficient energy solutions for society. At the same time, new energy power enterprises should actively explore and utilize new financing tools, such as issuing green bonds and green funds, to obtain long-term stable financial support and provide a solid economic foundation for the sustainable development of new energy projects.

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