Research on the Impact of Energy Efficiency on Firm Performance Based on the Mediating Effect of the Level of Green Innovation

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Abstract. Against the backdrop of global environmental change and China's "dual carbon" goal, enhancing energy efficiency is vital for enterprises' low-carbon development. This empirical investigation selects 51 A-share listed enterprises within the energy sector as the research sample, spanning a time frame from 2013 to 2023, measures their energy consumption and green innovation, and analyzes the impact of energy efficiency on enterprise performance and the role of green innovation by constructing regression models and mediating effect models. The empirical findings demonstrate that energy efficiency exerts a statistically significant positive impact on corporate performance, with green innovation serving as a mediating mechanism in this relationship. Specifically, a 1% increase in energy efficiency can drive a 0. 069% improvement in enterprise performance, and green innovation can further amplify this effect by 0. 113%. The heterogeneity analysis finds that the regression coefficient of energy efficiency in state-owned enterprises is 0. 103 (highly significant with a 1% significance criterion), while that in non-state-owned enterprises is -0. 050 and not significant; The regression coefficient of energy efficiency in central region enterprises is 0. 111 (significant at the 1% level), while the coefficients in eastern and western regions are negative. This study innovates the measurement system of energy efficiency by converting various energy consumptions into standard coal, deepens the investigation into the mediating mechanism of green innovation with patent application data as the index, and discusses the heterogeneity of property rights and regions, providing theoretical and practical references for enterprises to optimize energy structure and governments to formulate policies.

Keywords: Enter key words or phrases in alphabetical order, separated by commas.

1. Introduction

With the global push for sustainable development and China's "carbon peak and carbon neutrality" goals, enhancing energy efficiency is key for enterprises' energy structure optimization. The 20th National Congress report urged accelerating green development, guiding energy efficiency and green innovation efforts. For SMEs, crucial to the national economy, improving energy efficiency impacts competitiveness and national emission reduction goals. Yet, traditional high-energy, low-efficiency production hampers performance growth. The urgent challenge lies in leveraging green innovation to overcome resource constraints and boost efficiency and profits. China's energy policies, like the 14th Five-Year Strategic Plan for Green Industrial Development, emphasize integrating energy efficiency with green tech innovation. By positioning innovation-driven efficiency improvements and green R&D as key development directions, these policies provide institutional support for green transformation. This context makes exploring SMEs' green innovation paths both timely and significant.

Existing research confirms energy efficiency enhances corporate performance, with green innovation mediating environment-performance linkages and sectoral/regional variations in energy efficiency. However, by conducting a review of the existing literature, it is found that there are still significant gaps in key areas: 1) Systematic investigation of green innovation's mediating mechanisms between efficiency and performance, particularly regarding technological transformation pathways; 2) Comprehensive analysis of enterprise heterogeneity, especially the moderating effects of ownership structures and regional disparities within integrated frameworks. Current research has not fully explored these micro-level dynamic changes, so industry-specific research analysis is needed.

This research employs benchmark regression models to empirically examine the direct effect of energy efficiency on corporate performance, leveraging panel data from 51 A-share listed enterprises in the energy sector spanning the period 2013–2023. It establishes a transmission mechanism model with green innovation as the mediating variable to explore how energy efficiency influences corporate performance through green innovation pathways. The research focuses on revealing the extent and mechanisms by which their synergy promotes enterprise economic development, providing theoretical and practical insights for coordinating energy efficiency improvement with innovation-driven strategies in energy enterprises.

This paper makes marginal contributions in many aspects. In terms of indicator measurement, this paper innovates the indicator system of energy efficiency measurement and enriches the existing research system. In terms of research scope, this study focuses on energy-sector listed enterprises and employs benchmark regression models to empirically analyze the direct effect of energy efficiency on corporate performance; This study further employs a mediating effect model to systematically explore how green innovation mediates the relationship between energy efficiency and corporate performance, providing critical theoretical support for optimizing corporate energy structures and promoting high-quality development. At the same time, combined with heterogeneity analysis, this paper discusses the differentiated impacts of enterprise nature, industry attribute and regional characteristics on the synergistic effect between energy efficiency and green innovation. In terms of policy recommendations, according to the empirical results, and puts forward multidimensional linkage-technology-"policy market" strategy, both the government macroeconomic regulation and control, coordination and focus on enterprise technological innovation and market mechanism, improve the green innovation incentive mechanism for the government, enterprises to optimize energy management practice provides valuable reference practice.

2. Literature review

In the discussion of the impact of the energy efficiency of enterprise performance, the level of green innovation as an important intermediary variable, received extensive attention of the academia during the recent period. Informed by previous studies, this paper reviews the literature from three aspects of energy efficiency, enterprise performance and green innovation level to provide theoretical support for subsequent research.

2.1. Energy efficiency and enterprise performance

For enterprises, the ultimate goal of all improvement measures is to improve business performance. In recent years, the inquiry into the nexus between energy efficiency and corporate performance has emerged as a focal point in academic discourse. Early studies focused on the direct impact of energy efficiency on production costs, and proved that optimizing energy utilization can significantly reduce the operating costs of enterprises, thus improving the profit margin [1]. On the one hand, efficient energy management can enhance the market competitiveness of enterprises [2]. Especially under the "dual carbon" target, enterprises with high energy efficiency are more likely to win the favor of consumers and capital markets. On the other hand, the improvement of energy efficiency is often accompanied by technological innovation and management optimization, forming a positive cycle and promoting the enhancement of total factor productivity of enterprises [3] [4]. However, there are still limitations in the existing research. In the future, we can start from a more micro perspective and long-term tracking analysis to provide more targeted theoretical support for enterprise practice and policy making.

2.2. Mediating effect of green innovation level

The level of green innovation is the ability of enterprises to achieve energy conservation, emission reduction and efficient utilization of resources by means of technological innovation under the guidance of the concept of environmental protection and sustainable development [5]. Existing research points out that the level of green innovation significantly affects the performance of enterprises. Pollution charges can "force" enterprises to improve their green innovation ability, while environmental protection subsidies may "crowd out" enterprises' green innovation ability [6]. This conclusion reveals that different environmental regulation tools have differentiated impacts on the level of enterprise green innovation. Reasonable environmental regulation policies can encourage enterprises to increase investment in green innovation, improve energy efficiency, and achieve the double dividend of economy and environment [7]. Furthermore, corporate green environmental protection practices have a significantly positive impact on environmental performance, and indirectly affect economic performance through environmental performance as a mediating variable [8] [9]. Therefore, the level of green innovation can not only improve the environmental performance of enterprises, but also help to improve the economic performance of enterprises, even if this improvement may be indirect. At the same time, energy efficiency is closely related to the level of green innovation, and the two are closely related and act together on enterprise performance. On the one hand, improving energy efficiency can help enterprises reduce production costs, enhance competitiveness, and provide material basis and economic suppor for green innovation [10]. On the other hand, the improvement of green innovation level can promote enterprises to adopt more energy-saving and environmentally friendly production technologies and processes, thus improving energy efficiency [11].

The previous studies have provided A good foundation and beneficial enlightenment for this paper.

3. Research design

3.1. Sample selection and data sources

This study employs energy enterprises listed on the main boards of Shanghai and Shenzhen Stock Exchanges during 2013–2023 as the initial sample pool. The sample filtering process follows these sequential steps: (1) excluding ST and *ST firms; (2) removing entities with asset-liability ratios exceeding 1; (3) eliminating observations with missing data. This screening yields a panel dataset comprising 561 valid observations. Empirical data used in this research are primarily drawn from the CSMAR and Wind databases, with supplementary information sourced from the CSDN platform.

3.2. Variable selection and measurement

3.2.1. Energy consumption

The energy consumption of listed enterprises encompasses diverse energy types, including electrical energy, coal, petroleum, natural gas, and other forms of energy resources. Due to the differences in the energy released during the consumption of various energy, for the convenience of use, it is converted into unified standard coal according to the following formula:

Converted into unified standard coal = water consumption ×0. 0002429+ power consumption ×1. 229+ raw coal consumption ×0. 7143+ natural gas consumption ×13. 3+ gasoline consumption ×1. 4714+diesel consumption ×1. 4571+ central heating ×0. 03412

The conversion coefficient specified in the aforementioned formula is derived from the China Energy Statistical Yearbook published by the Energy Division of the National Bureau of Statistics. Standard coal equivalent is employed as the measurement variable for annual energy consumption of listed companies, thereby mitigating the bias arising from differences in energy types and calorific values.

3.2.2. Green innovation

To curtail energy consumption and environmental degradation, enterprises are encouraged to proactively institute energy-saving and emission-reduction protocols while enhancing technological innovation and green development initiatives. The quantity of invention, utility model, and design patent applications filed in the current year serves as a proxy for measuring the current-year level of green innovation.

3.2.3. Control variables

Table 1. Variable definitions

Types of variables	Variable name	Symbol of variable	Variable measure
Dependent variable	Business performance	CFP	(Net profit/total assets) ×100%
Independent variable	Energy consumption	Reci	Converted to uniform standard coal
Mediating variables	Green innovation	Green	The natural logarithm of a firm's total filings for invention, utility model and design patents in that year plus one
Control variables	Shareholding ratio of the largest shareholder	Top	Shareholding of the largest shareholder
	Asset-liability ratio	Lev	(Total liabilities/total assets) ×100%
	Size of enterprise	Size	Natural logarithm of total assets in the year at the end of the period
	Current ratio	Cr	(Current liabilities/current assets) ×100%
	Growth	Growth	[(current period operating income- previous period operating income)/previous period operating income] ×100%
	Effect of enterprise nature	Company	Firm nature dummy variable, assigned a value of 1 if it belongs to this nature and 0 otherwise
	Region effect	Place	Place dummy variable assigned a value of 1 if it belongs to the place and 0 otherwise

Building on existing studies, we selected asset-liability ratio (Lev), enterprise Size (Size), liquidity ratio (CR) and other characteristic variables as control variables. See Table 1 for the names, codes and definitions of the main variables.

3.3. Descriptive statistical analysis

There are various types of data applied in this paper. In order to ensure that the results of the empirical analysis will not be affected by the units, all the data involved are standardized by Max-Min method before the empirical analysis.

Table 2 reports the descriptive statistical results of key variables for the sample enterprises. Corporate financial performance (CFP) has a mean of 0. 598 and median of 0. 595, with a standard deviation of 0. 101, showing significant variation in performance. Return on equity (ROE) has a mean of 0. 693 and median of 0. 696, with a standard deviation of 0. 071, indicating large differences in ROE. The energy consumption variable (RECI) has a mean of 0. 468 and median of 0. 461, with a standard deviation of 0. 254, reflecting diverse energy consumption levels. The green innovation variable (Green) has a mean of 0. 181 and median of 0. 100, with a standard deviation of 0. 219, suggesting significant differences in green innovation performance. Large standard deviations of control variables imply wide variation among companies, potentially influencing corporate performance.

Table 2. Descriptive statistical results of variables

Variable	Obs	Mean	50%	Std. Dev.	Min	Max
CFP	561	.598	.595	.101	0	1
ROE	561	.693	.696	.071	0	1
Reci	561	.468	.461	.254	0	1
Green	561	.181	.100	.219	0	1
Top	561	.445	.457	.209	0	1
Lev	561	.357	.378	.15	0	1
Size	561	.414	.418	.206	0	1
Cr	561	.074	.044	.109	0	1
Growth	561	.016	.012	.049	0	1

3.4. Model Setup

To investigate the effect of energy efficiency on enterprise performance and to investigate the role of green innovation as a mediating variable, this paper constructs regression models (1), (2), and (3), which are respectively used to test the benchmark regression model and the mediating effect model. The specific regression model settings are as follows:

$$CFP_{it} = \alpha_0 + \alpha_1 Reci_{it-1} + \alpha_i Control_{it-1} + \varepsilon_{it} \tag{1}$$

$$GREEN_{it} = \alpha_0 + \alpha_1 Reci_{it-1} + \alpha_i Control_{it-1} + \varepsilon_{it} \tag{2}$$

$$CFP_{it} = \alpha_0 + \alpha_1 Reci_{it-1} + \alpha_2 GREEN_{it-1} + \alpha_2 Control_{it-1} + \varepsilon_{it} \tag{3}$$

Among them, the dependent variable in regression model (1) and regression model (2) is enterprise performance, and the dependent variable in regression model (3) is the level of green innovation;the independent variable in regression model (1), regression model (2), and regression model (3) is energy efficiency, reflecting the performance of enterprises in the utilization and consumption of energy;green innovation is the mediating variable in regression model (2). The control variables in regression model (1), regression model (2), and regression model (3) are$Control_{it-1}$, which are the proportion of the largest shareholder (Top), the debt-to-asset ratio (Lev), enterprise scale ($Size$), current ratio (Cr), growth ($Growth$), enterprise nature ($Company$), and regional effect$Place$), respectively.

4. Empirical study

4.1. Analysis of benchmark regression results

Before the benchmark regression, this paper first conducts the F test and hausman test, and the results pass, and the VIF value is 1. 83, indicating that there is no serious collinearity problem. Based on the correlation analysis results, this paper estimates Model (1) through the benchmark regression method in order to test the impact of enterprise energy efficiency on enterprise performance, and the test findings are presented in Table 3. From the regression results of Column (1) in Table 3, it can be seen that the regression estimated coefficient of CFP is significantly positive at the confidence level of 1%, indicating that the better the enterprise energy efficiency performance is, the better the enterprise performance is. Combined with the comparative analysis of the results in Column (1) and column (2), the impact of energy efficiency on corporate performance is 0. 078 and 0. 069, respectively. The results of this test fully show that by improving the efficiency of energy use, considering the regression results with control variables added in Column (2), it can be seen that this does not increase the total cost of the enterprise, although it has a negative impact on the asset-liability ratio, these initiatives not only substantially enhance corporate operational efficiency and mitigate investment risks for stakeholders but also foster long-term organizational sustainability. Thereby driving comprehensive improvements in firm-level efficiency.

Table 3. Test results of the impact of energy efficiency on enterprise performance

	(1)	(2)
	cfp	cfp
reci	0. 078***	0. 069***
	(4. 716)	(4. 430)
top		0. 073***
		(3. 541)
lev		-0. 264***
		(-8. 209)
size		0. 112***
		(4. 823)
cr		-0. 042
		(-0. 951)
growth		0. 104
		(1. 337)
_cons	0. 561***	0. 582***
	(63. 949)	(32. 560)

(***p<0. 01, **p<0. 05, *p<0. 10)

4.2. Mediating effect test

Regression Model (2) and regression Model (3) are estimated through the mediating effect model and Table 4 is obtained. Table 4 reports the mediating effect analysis results with green innovation as the mediating variable. According to the data in Column (1), the mediating variable green innovation has a beneficial effect on the explanatory variable energy efficiency at the confidence level of 1%, which is 0. 057. This finding fully demonstrates that green innovation exerts a positive influence on the enhancement of corporate energy efficiency. Re-analyzing the data in Column (2), the data show that the mediating effect of green innovation between energy efficiency and enterprise performance is positive, which is 0. 113. Integrating the comprehensive analysis of the test outcomes presented in Table 4, the mediating effect level of green innovation has a significant impact on both energy efficiency and enterprise performance. This shows that by improving the level of green innovation, enterprises can not only have a direct positive impact on the improvement of energy efficiency, but also have a positive impact on some indicators that measure the economic significance of enterprises. Meanwhile, it is crucial to account for the potential adverse effects of green innovation, thereby enhancing the efficacy of green innovation initiatives and safeguarding the long-term sustainability of enterprises. In summary, while green innovation is crucial to the development of energy enterprises, this also indicates that enterprises should attach importance to the influence of multiple indicators in their development process.

Table 4. Test results of mediating effect level of green innovation

	(1)	(2)
	green	cfp
reci	0. 057***	0. 066***
	(2. 770)	(3. 795)
top	-0. 061	0. 060
	(-1. 252)	(1. 459)
lev	0. 039	-0. 437***
	(0. 678)	(-9. 125)
size	0. 593***	0. 009
	(7. 491)	(0. 128)
cr	0. 054	-0. 073
	(0. 514)	(-0. 814)
growth	-0. 082	0. 083
	(-0. 897)	(1. 083)
green		0. 113***
		(3. 010)
_cons	-0. 081**	0. 676***
	(-2. 105)	(20. 806)

(***p<0. 01, **p<0. 05, *p<0. 10)

4.3. Heterogeneity analysis

4.3.1. Heterogeneity of property rights

Within the institutional context of China's socioeconomic system, marked divergences are observed between state-owned and non-state-owned enterprises in dimensions such as social responsibility fulfillment, economic performance, and policy support. On the one hand, in terms of the comparison between the two, owing to the institutional political linkages between state-owned enterprises and the government, the measures and policies they take are usually to fulfill their due social responsibilities; Non-state-owned enterprises are primarily oriented toward enhancing corporate economic benefits and realizing profit maximization. Thus, when state-owned enterprises demonstrate heightened attention to energy consumption, it not only signals their robust commitment to sustainable development but also enables them to exert a leading influence on non-state-owned enterprises, thereby eliciting a more pronounced response from societal stakeholders. On the other hand, as the government assumes a pivotal role in the amelioration of the energy environment, state-owned enterprises need to take corresponding measures to respond to the policy. Based on the analysis of this study, state-owned enterprises demonstrate more pronounced energy efficiency performance and green innovation outcomes. According to the results in Table 5, Column (1) is for soes and column (2) is for non-soes. In non-state-owned enterprises, the regression coefficients of Reci are not significant; In soes, the regression coefficients of Reci are all significant, which is consistent with the inference.

Table 5. Heterogeneous regression analysis of the differences in the nature of enterprises

	(1)	(2)
	cfp	cfp
reci	0. 103***	-0. 050
	(6. 026)	(-1. 443)
top	0. 052**	0. 067
	(1. 998)	(1. 637)
lev	-0. 269***	-0. 359***
	(-7. 780)	(-3. 974)
size	0. 097***	0. 293***
	(3. 972)	(4. 411)
cr	-0. 048	-0. 026
	(-1. 091)	(-0. 150)
growth	0. 084	0. 153
	(1. 044)	(0. 749)
_cons	0. 584***	0. 611***
	(28. 722)	(12. 977)

(***p<0. 01, **p<0. 05, *p<0. 10)

4.3.2. Regional heterogeneity

Table 6. Heterogeneity regression analysis of regional differences

	(1)	(2)	(3)	
	cfp	cfp	cfp	
reci	-0. 003	0. 111***	-0. 004	
	(-0. 145)	(4. 423)	(-0. 128)	
top	0. 060**	0. 034	0. 151***	
	(2. 098)	(0. 890)	(2. 998)	
lev	-0. 197***	-0. 409***	-0. 222***	
	(-3. 954)	(-6. 197)	(-3. 819)	
size	0. 121***	0. 236***	0. 434***	
	(4. 161)	(3. 784)	(5. 002)	
cr	0. 017	-0. 016	0. 538**	
	(0. 333)	(-0. 104)	(2. 525)	
growth	0. 121	0. 081	4. 016***	
	(0. 825)	(0. 854)	(3. 945)	
_cons	0. 577***	0. 597***	0. 366***	
	(24. 289)	(14. 502)	(5. 945)	

(***p<0. 01, **p<0. 05, *p<0. 10)

Regional economic disparities in China disparities significantly shape energy policy impacts, with central regions exhibiting higher traditional energy intensity due to concentrated thermal power and chemical industries, yet benefiting from late-mover technological advantages and cost reductions under the "Central China Rise" and "dual carbon" strategies. State-owned enterprises here leverage resource integration and industrial chain optimization to enhance performance through scale effects. Meanwhile, eastern coastal areas experience weakened energy efficiency-performance correlations as policies shift from growth protection to economic restructuring, reflecting inevitable trade-offs during industrial upgrading. In contrast, western regions prioritize immediate economic gains over energy efficiency improvements, where fiscal constraints amplify corporate costs in green innovation and energy management, yielding limited performance benefits despite being manufacturing relocation hubs. These spatial variations underscore how regional development priorities and institutional capacities mediate energy transition outcomes.

Therefore, the energy consumption performance and the value effect of green innovation expected in this paper are more obvious in the central region. According to the results in Table 6, Column (1) corresponds to the eastern region, Column (2) to the central region, and Column (3) to the western region.

5. Conclusions and suggestions

This study employs a research sample of A-share listed companies in China, deriving data on corporate energy efficiency performance, green innovation, and firm performance through manual collation and database retrieval. It investigates the impact of energy efficiency on firm performance and its transmission mechanisms, with a focus on the mediating role of green innovation. Then, we draw the following conclusions: (1) Enhanced energy efficiency performance significantly boosts the operational performance of manufacturing enterprises. Additionally, improvements in energy efficiency exert significant positive or negative effects on corporate characteristics such as equity structure and asset composition. While fulfilling environmental responsibilities, enterprises should not only pay attention to energy performance, but also pay attention to the structure and status of financial capital. (2) The mediating effect test results show that energy efficiency promotes the improvement of enterprise performance under the influence of green innovation. The better the degree of green innovation is, the more the enterprise performance is improved. (3) Through heterogeneity research analysis, the impact of energy efficiency on enterprise performance is restricted by regions and property rights. State-owned enterprises in more economically developed areas perform better in fulfilling environmental responsibilities, thereby enhancing energy efficiency and promoting enterprise performance.

Drawing on the research findings, this study proposes the following policy recommendations: (1) Energy enterprises are advised to prioritize the enhancement of energy efficiency, shift away from development models dependent on non-renewable energy sources, and optimize resource allocation by integrating assets and fulfilling environmental responsibilities. Such initiatives can facilitate the efficient utilization of energy, promote energy conservation and emission reduction, and ultimately elevate corporate performance and sustainable development through the creation of brand equity. (2) Enterprises should make clear the role of green innovation as the key path of energy transition, which not only affects energy consumption and environmental responsibility, but also involves economic decision-making and strategic deployment; Enterprises should learn from successful experiences, explore the optimal path of performance improvement suitable for themselves, and strengthen the synergistic effect between energy efficiency and sustainable development. (3) The government needs to implement differentiated regulation according to regional differences and property rights characteristics: local governments should formulate policies based on regional reality and industry status quo, and dynamically optimize measures through pilot mechanisms; State-owned enterprises are expected to assume a leading role in guiding non-state-owned enterprises to implement policy initiatives;At the same time, the government should provide financial and technical support to build a multi-party collaborative system to promote energy efficiency improvement, green innovation and enterprise performance improvement.

In this regard, this paper points out that follow-up research can be expanded in the following directions: including small and medium-sized enterprises in the research category and carrying out cross-industry comparative analysis to verify the general applicability of the research conclusions; introducing a time-lag effect model to analyze the long-term interaction between energy efficiency and green innovation over a 5 to 10-year period;exploring the synergistic effects of policies such as carbon taxes, subsidies, and emission trading;and conducting an in-depth investigation into the role of management cognition and organizational learning mechanisms in the transmission process from energy efficiency to green innovation.

References

[1] Ma Xiaojun, Chen Ruimin, Su Heng. [1] The driving factors and decoupling analysis of industrial energy consumption in China [J]. Statistics and Information Forum, 2021, 36 (03): 70 - 81].

[2] DU W Q, GUO S J. Double carbon targets under the green energy efficiency improvement path research in China [J]. Journal of management modernization, 2021, 9 (6): 96 - 99.

[3] Zhang, P. & Tu, X. Manufacturing agglomeration, technological progress and total factor energy efficiency of enterprises [J]. China Industrial Economics, 2022, (07): 103 - 121].

[4] WANG Yafei, ZHANG Luyao, ZHONG Min. [4] [WANG Y F, ZHANG L Y, ZHONG M. Research on the influence mechanism of data factor utilization on total factor energy efficiency of enterprises [J/OL]. Soft science, 1 - 9.

[5] LAI J M. The impact of environmental rights trading on corporate green innovation: from the perspective of sulfur dioxide emission trading policy [J]. Soft science, 2024, 38 (02): 117 - 123.

[6] LIU Shuru, Li Mingyuan, Song Wei. Double carbon constraints, the energy consumption structure and the total factor of energy efficiency [J]. Journal of statistics and decision, 2024, 40 (02): 83 - 88.

[7] Wang Z Y, Cao Y, Lin S L. [7] [Wang Z Y, CAO Y, Lin S L. Characteristics and heterogeneity of environmental regulation on corporate green technology innovation: based on green patent data of Chinese listed companies [J]. Science research, 2021, 33 (5): 6, 909 - 919 + 929.

[8] Li Qing-yuan, XIAO Ze-hua. [8] [Li Q Y, XIAO Z H. Heterogeneous environmental regulation tools and corporate green innovation incentives: evidence from listed companies' green patents [J]. Economic Research Journal, 2020, 55 (09): 192 - 208.

[9] Zeng Ping, Xiao Jing, Li Dongwei, et al. Dual Institutional Pressures, Green Innovation and Enterprise Environmental Performance: The Moderating Role of Environmental Ethics [J/OL]. Journal of Industrial Engineering and Engineering Management, 1 - 15. 2025. 05. 005.

[10] Chai Jian, Tian Lingyue, Zhang Xiaokong. [2] [CHAI J, TIAN L Y, ZHANG X K. Dynamic evolution and influencing factors of coupled and coordinated development of economy-energy-environment system. Management Review, 2024, 36 (01): 29 - 41.

[11] Shao Shuai, Fan Meiting, Yang Lili. [3] [ShaO S, FAN M T, Yang L. Economic restructuring, green technology progress and China's low-carbon transformation: an empirical study from the perspective of overall technology frontier and spatial spillover effect. Management World, 2020, 38 (02): 46 - 69+4 - 10.