Proceedings of ICMRED 2025 symposium: Analyzing the Impact of Governmental Environmental Attention on Enterprises' ESG Performance
DOI: 10.54254/2754-1169/2025.MUR22460

Does Climate Risk Promote Green Innovation in Enterprises?

Fengye Lyu

Business School, Beijing Normal University, Beijing, China
202211030017@mail.bnu.edu.cn

Abstract: Can enterprises respond to climate risks through green innovation? This is a question of shared concern across society. Using a sample of Chinese A-share listed companies from 2009 to 2022, this paper empirically examines the impact of climate risk on green innovation in enterprises and its mechanisms. The study finds that climate risk can indeed significantly promote green innovation in enterprises. On average, for every one standard deviation increase in the climate risk index, the level of green innovation in enterprises rises by 2.196 percentage points. Mechanism analysis reveals that climate risk drives enterprises to engage in green innovation through digital transformation and R&D investment. This promoting effect is stronger in non-state-owned enterprises and high-pollution industries. Further research finds no significant relationship between green innovation and green total factor productivity in enterprises, suggesting that the motivation for green innovation may not solely arise from addressing climate risks but could also be influenced by government subsidies and other factors. The conclusions of this paper are significant for improving enterprises' ability to cope with climate risks and provide theoretical support for governments in formulating climate adaptation policies.

Keywords: Climate risk, Green innovation, Digital transformation

1. Introduction

Since the 1990s, the frequent occurrence of extreme climate events such as high temperatures, droughts, floods, and typhoons has made countries around the world aware of the severity of global climate issues [1]. Climate change poses significant threats to social production and human activities. According to data from the United Nations website, for every 1°C increase in temperature, food production decreases by approximately 5%. Furthermore, global temperature rise also leads to sea level rise, putting immense pressure on the living space of coastal cities. Google Trends shows that since 2015, searches for keywords such as "climate" and "climate risk" have steadily increased, with "climate risk" rising from 20% of its peak in January 2015 to 88% in January 2025. Public attention to climate risks continues to grow, and calls for adapting to climate change are becoming increasingly urgent.

As a major emitter of greenhouse gases, China has always attached great importance to climate change issues, taking proactive measures to promote economic green transformation, reduce extreme climate events caused by human activities, and address the threats of climate change. The revised 2022 "National Strategy for Climate Change Adaptation 2035" also provides guidance for strengthening climate adaptation capacity through scientific planning and innovative mechanisms, enhancing the nation's ability to address climate risks.

DOI: 10.54254/2754-1169/2025.MUR22460

Existing studies have analyzed the economic consequences of climate risks from both macro and micro perspectives. For the former, some literature focuses on the agricultural economy, examining the negative effects of climate risks on agricultural output [2]. Other studies explore the impact of climate risks on financial stability, including the debt levels of macroeconomic entities, foreign direct investments, and bank risk-taking [3-5]. As for the latter, existing literature examines the effects of climate risks on corporate investment, financing, and value, finding that extreme climate risks strongly encourage enterprises to allocate investments to regions with lower climate risks, with profit-driven objectives and risk mitigation strategies serving as key factors in this process.[6]. Other studies suggest that climate policy shocks can significantly increase the bond financing costs of enterprises, as evidenced by higher credit spreads for bonds issued by companies with high climate policy sensitivity compared to others [7]. Regarding corporate value, some studies find that climate risks have a significant negative impact on corporate value, with corporate returns and credit risks serving as effective channels for the negative impact of climate risks on corporate value [8].

Based on a brief review of the literature in related fields, this paper finds that while the economic consequences of climate risks have received widespread attention and significant research progress has been made in areas such as economic growth, financial stability, and social inequality, these studies mainly focus on the impact of climate risks on enterprises, neglecting how enterprises take measures to address the threats of climate change. Climate risks are closely related to sustainable development. Under pressure from governments and the public, it is necessary to answer whether enterprises can respond to climate risks through green innovation. As the physical and transitional risks brought about by climate change intensify, whether climate risks can drive companies toward undertaking environmentally sustainable innovations. has become an increasingly important and urgent research question.

Building on existing research, this paper uses data from Chinese A-share listed companies from 2009 to 2022 to establish a fixed-effects regression model. The results indicate that climate risks can compel enterprises to engage in green innovation, and this result remains robust after changing the measurement methods of explanatory and explained variables, altering the sample scope, and incorporating province-year interaction fixed effects.

In terms of the pathways through which climate risks compel enterprises to engage in green innovation, this paper finds that corporate digital transformation and R&D investment play mediating roles. Additionally, this paper finds that the green innovation level of private enterprises is more significantly influenced by climate risks, as is the green innovation level of enterprises in high-pollution industries. However, corporate green innovation does not exert a notable influence on green total factor productivity, suggesting that the motivation for green innovation may not entirely stem from improving green production capacity to address climate risks but may also be influenced by other factors, such as government subsidies.

The marginal contributions of this paper may include: 1) discussing micro-level corporate responses to climate risks, deeply analyzing the impact of climate risks on corporate green innovation behavior. The research conclusions not only fill a gap in the field but also provide empirical evidence for governments to formulate targeted innovation incentive policies under climate risks, with practical significance. 2) Further discussing the relationship between green innovation and green production levels, supplementing existing literature on corporate "greenwashing" behavior.

This paper is organized as follows: Section 2 provides a literature review and theoretical analysis; Section 3 introduces the research design; Section 4 reports the main research results and discusses how climate risks influence corporate green innovation; and the final section presents conclusion and policy recommendations.

DOI: 10.54254/2754-1169/2025.MUR22460

2. Literature review and theoretical analysis

2.1. The economic impact of climate risks

Climate risks are generally divided into physical climate risks and transition risks. Physical risks are related to the physical impacts of severe climate events or chronic conditions, while transition risks arise in the process of shifting towards a low-carbon economy, primarily influenced by policies, regulations, and societal expectations and pressures[9]. The economic consequences of climate risks have been a major focus of academic research since the 1990s, with numerous studies examining their impacts from various perspectives.

Climate risks can directly negatively impact economic growth. Basic production factors in modern economies, such as labor and crops, exhibit highly non-linear responses to local temperatures even in affluent countries [10]. Furthermore, global warming is significantly positively correlated with the probability and degree of seriousness of natural disasters, like droughts and floods [11]. The direct damage to output caused by natural disasters can result in substantial economic losses.

Climate risks may also have negative economic consequences by affecting the stability of financial systems. Studies have shown that climate risks can increase regional financial risk levels, and this impact has spatial spillover effects, potentially triggering systemic risks. Extreme climate risks primarily elevate regional financial risks through two channels: the household sector and the corporate sector. In terms of heterogeneity, financial markets in central and western regions and areas with higher climate change intensity are more vulnerable to extreme climate events [12].

Some studies examine the risk of significant asset stranding in the fossil fuel industry under the current climate change context. Substantial capital investments related to fossil fuel extraction, processing, transportation, and power generation are subject to devaluation and stranding. Given the critical role of the fossil fuel industry in the economy, significant asset stranding risks could trigger systemic risks.

Climate risks also manifest in economic inequality across regions and income groups, as well as their impact on social welfare. Research indicates that globally, the negative impacts of climate warming are more pronounced in low-income countries, potentially exacerbating economic inequality [13].

From the above findings, it is evident that there is extensive literature on the economics of climate change, but limited research on how enterprises adapt to climate change through innovation. Investigating climate change-related patent activities and the barriers they face is valuable [14].

2.2. Analysis of factors influencing corporate green innovation

Existing research on the factors influencing corporate green innovation primarily focuses on financial market mechanisms and environmental regulations.

Regarding financial market mechanisms, studies have shown that after the implementation of the "Green Credit Guidelines," green innovation activities in industries subject to green credit restrictions became more active compared to industries not subject to such restrictions. However, the quality of green innovation did not significantly improve [15]. Other studies find that green credit policies promote green innovation among upstream and downstream firms in high-pollution industries but suppress green innovation among upstream firms in green industries, while promoting green innovation among downstream firms [16]. Additionally, literature examines the role of capital account inflows and outflows on corporate green innovation levels and their mechanisms [17].

In terms of environmental regulations, existing literature explores the influences of formal and informal environmental regulations on corporate green innovation. Traditional neoclassical theory posits that formal environmental regulations internalize externalities, leading to increased pollution

DOI: 10.54254/2754-1169/2025.MUR22460

costs that inhibit corporate green innovation. Another perspective, based on the "Porter Hypothesis," argues that environmental regulations incentivize firms to innovate green technologies to reduce pollution costs, thereby building a long-term competitive advantage [18].

Informal environmental regulations, such as social opinion [19], consumer environmental awareness, and supply chain linkages [20], are also found to promote corporate green innovation. Additionally, studies find that ESG ratings [21] and digital transformation [22] positively influence corporate green innovation levels.

2.3. Theoretical analysis of the impact of climate risks on corporate green innovation

Climate change, represented by extreme climate events, not only physically impacts enterprises but also generates policy pressures and societal expectations that compel firms to transform.

On one hand, climate change drives enterprises to undergo digital transformation to address environmental challenges through policy, market, and social responsibility pressures. Digital technologies help enterprises optimize resource allocation, improve production efficiency, reduce the costs of green technology R&D, and achieve green supply chain management. This shift offers technological backing and data infrastructure for green innovation, fostering the advancement and implementation of green technologies, thereby enhancing enterprises' green innovation levels and their capacity to cope with climate change.

On the other hand, R&D investment serves as both an essential resource guarantee for corporate green innovation and a critical channel for enhancing technological capabilities and innovation efficiency, driving the development and application of green technologies. Studies have shown that R&D investment is a key promoter of corporate green innovation [23].

Climate change compels enterprises to implement green innovation, which, as an essential means for firms to address climate change, produces outcomes (e.g., green technologies, green products) that significantly improve resource allocation efficiency and environmental management capabilities, thereby enhancing green total factor productivity. Moreover, policy incentives (e.g., green finance, tax incentives) and market demand (e.g., consumer preferences for green products) further reinforce this linkage effect.

When green innovation is directly applied to enterprises' internal production processes, it effectively optimizes resource allocation, reduces pollution emissions, and improves production efficiency. Enterprises need to integrate green innovation into production processes, effectively converting and implementing green technologies to make them core components of production.

Therefore, by promoting corporate green innovation, climate change not only helps enterprises adapt to external environmental changes but also, under certain conditions, improves their green total factor productivity.

Based on the theoretical analysis, this paper propose the hypotheses of this study:

H1: Climate change promotes corporate green innovation.

H2: Climate change promotes green innovation through increased R&D investment and digital transformation.

3. Research design

The core objective of this paper is to explore whether climate risks promote corporate green innovation, analyze the mechanisms through which climate risks influence green innovation, and investigate whether green innovation driven by climate risks contributes to enterprises' green production practices.

DOI: 10.54254/2754-1169/2025.MUR22460

3.1. Sample selection and data sources

This paper uses a sample of Chinese A-share listed companies from 2009 to 2022, excluding samples with missing key variables and companies classified as ST or ST*. The corporate green patent database from the Chinese Research Data Services Platform (CNRDS) provides data on green invention patents and green utility model patents from 2009 to 2022. Standardized temperature data at the prefecture level from 2009 to 2022 are sourced from observations at mainland China meteorological stations under CNDC. Other firm-level data are sourced from the CSMAR database, while prefecture-level data are obtained from the "China City Statistical Yearbook."

3.2. Econometric model design

To test the research hypotheses, the following fixed-effects model is constructed:

$$PATENT_{i,t} = \beta_0 + \beta_1 CRISK_{i,t} + \sum \beta_j Control_{i,t} + \sum Yecr + \sum Firm + \varepsilon_{i,t} \quad (1)$$

Where *PATENT* represents the dependent variable (corporate green innovation level), *CRISK* represents the independent variable (climate risk), and *Control* represents the control variables. $\beta 1$ is the coefficient of interest, reflecting the influence of perceived climate risks on corporate green innovation. ϵ represents the model's random disturbance term.

To account for the influence of unobservable variables, this model includes both year fixed effects and firm fixed effects.

The dependent variable of the article is corporate green innovation (PATENT). A commonly used method to measure corporate green innovation is to use the natural logarithm of the sum of 1 and the number of green patent applications by a company to represent its level of green innovation [24]. This study adopts the same approach, with green patent data sourced from CNRDS.

The independent variable of the article is climate risk (CRISK). Climate risk is measured as the ratio of the frequency of climate risk keywords in the Management Discussion and Analysis (MD&A) section of annual reports to the total length of the text. The scope of climate risk keywords is based on existing literature [25] and adopts an expanded set of 98 keywords covering three dimensions: acute risks, chronic risks, and transition risks. Among these, acute and chronic risks fall under physical risks. The content of listed companies' annual reports is processed and calculated using the corporate annual report text data from the WinGo Financial Text Data Platform.

Referring to the approach in existing literature [26], this study controls for the following variables: firm size (SIZE), years since listing (lnAGE), revenue growth rate (GROWTH), leverage ratio (LEV), return on assets (ROA), current asset ratio (CFO), CEO duality (DUALITY), shareholding ratio of the largest shareholder (TOP1), city-level per capita GDP (GDP), and city-level GDP growth rate (GDPGRO). The firm-level data is sourced from the CSMAR database, excluding samples of ST and ST* firms. Data on city-level per capita GDP and GDP growth rate is obtained from the China City Statistical Yearbook.

Additionally, to mitigate the influence of outliers, all continuous variables involved in the regression are subjected to 1% bilateral winsorization. The definitions of the main variables and the descriptive statistics are provided in Table A1 and Table A2.

4. Empirical results and analysis

4.1. Baseline estimation results

Table 1 presents the baseline estimation results on the impact of climate risk on firms' green innovation levels. It can be observed that the climate risk index consistently shows a significantly positive regression coefficient at the 1% level. The result remains valid after the inclusion of control

DOI: 10.54254/2754-1169/2025.MUR22460

variables. This indicates that the higher the climate risk in the firm's location, the higher the firm's level of green innovation. Specifically, a one-standard-deviation increase in the climate risk index raises the firm's green innovation level by 2.196 percentage points. This implies that when firms perceive climate risks, they respond to potential climate risk shocks through technological approaches represented by green innovation. The baseline regression results provide empirical evidence supporting Hypothesis 1. The mechanism through which firms engage in green innovation will be discussed in detail in the mechanism analysis section.

Table 1: Baseline regression results

	(1)
VARIABLES	PATENT
CRISK	12.98***
	(2.972)
Constant	0.367***
	(0.00726)
Observations	37,540
R-squared	0.708

4.2. Robustness tests

To eliminate potential issues such as measurement errors and omitted variable bias during the research process and ensure the reliability of the baseline regression results, this paper employs various methods for robustness checks. First, to rule out the possibility of measurement error, we use standardized temperature and the green patent applications to replace the core explanatory and explained variables, respectively. Second, we change the sample years to exclude possible interference from Covid-19 and "11th Five-Year Plan". Third, we use more stringent province-year interaction fixed effects to rule out the effects of omitted variables. These represent that our baseline result is robust. Due to space limitations, the above results are available from the authors upon request.

4.3. Mechanism analysis

Based on the research hypotheses, this paper considers the mechanism through which climate risk influences green innovation by driving firms to increase R&D investment and enhance their level of digital transformation. The focus here is to examine whether the explanatory variable, climate risk, exerts a significant positive impact on the mechanism variables and to explain, through economic theory or findings from existing literature, how the mechanism variables affect the dependent variable, firms' green innovation [27].

Specifically, referring to existing literature [28], this paper constructs a digital transformation index as a proxy variable for firms' digital transformation level (DIGIT) by conducting word frequency statistics on 99 keywords related to four dimensions: digital technology application, internet business models, intelligent manufacturing, and modern information systems, using annual reports of listed companies. For firms' R&D investment, considering data availability, this paper uses the logarithm of the amount of R&D investment as a proxy variable for R&D (R&D).

Table A4 presents the regression results of the mechanism analysis for firms' digital transformation and R&D investment. From column (1), it can be concluded that a one-unit increase in the climate risk index raises firms' digital transformation levels by 21.01%. From column (2), it can be concluded that a one-unit increase in the climate risk index raises firms' R&D investment by

DOI: 10.54254/2754-1169/2025.MUR22460

7.87%. Considering the fact that companies are digitally transforming and greening their innovations [29,30], this will inevitably contribute to the greening of listed companies.

Table A5 further examines the structural changes in R&D investment. Column (1)-(3) shows that climate risk primarily promotes green innovation by increasing the absolute value of firms' R&D personnel and financial investment. The capitalization rate of R&D investment in Column (4) shows that when facing higher climate risks, firms may prioritize short-term gains and tend to expense more R&D expenditures directly rather than capitalizing them. There are multiple potential funding sources for firms' increased R&D investment. An increase in firms' operating revenue provides a more abundant source of funding for R&D, especially for highly profitable firms that are more capable of allocating part of their profits to R&D. Government subsidies are also a significant driver of increased R&D investment. By providing direct financial support, tax reductions, or specialized R&D incentive policies, governments reduce firms' R&D costs and encourage innovation activities. Furthermore, external financing can also provide firms with additional financial support.

We use 2011 as the base year to construct categorical variables. Specifically, the categorical variables are set to 1 when the value of a firm's operating income and government subsidy in 2011 is greater than the median of all firms in that year, and 0 otherwise, and then the categorical variables are interacted with the core explanatory variables to obtain climate risk levels (crisk_subsidies) and between operating revenue and climate risk levels (crisk_revenue).

The results in Table A6 show that firms receiving higher subsidies and generating higher revenues perform better in green innovation. Combined with the results in column (1) of Table A4, which demonstrate that R&D investment is an important mechanism through which climate risk promotes firms' green innovation, it can be concluded that the funding sources for firms' increased R&D investment include both increased operating revenue and higher government subsidies. Facing the threat of climate risk, firms extract funds from their operating revenue and government subsidies to increase R&D investment, thereby enhancing their green innovation levels and improving their ability to respond to climate risks. Further Research

We further examine the heterogeneity in the relationship between climate risk and green innovation based on firm ownership characteristics and industry classification. SOEs and non-SOEs differ significantly in terms of objectives, resource allocation, and responses to external pressures. Different industries exhibit significant differences in technological characteristics, policy pressures, and market demand, which in turn influence firms' green innovation. High-pollution and high-emission industries typically face stricter environmental regulations and greater social pressure. We categorize firms into whether they are state-owned or not on the one hand; on the other hand, we classify firms according to the pollution intensity of the industry into whether they are high polluting industry firms or not.

The coefficient of integration term in Table A7 show that the promoting effect of climate risk on green innovation is greater for non-SOEs than for SOEs. Compared to SOEs, non-SOEs respond more actively to market changes brought about by climate risk, leveraging green innovation to seize opportunities and enhance the competitiveness of their products and services.

From the perspective of industry attributes, the promoting effect of climate risk on green innovation is greater for non-high-pollution firms than for high-pollution firms. This may be because green innovation in high-pollution firms is more driven by compliance needs, i.e., to reduce the pressure of environmental regulation and the risk of fines. In contrast, green innovation in non-high-pollution firms is more market-driven.

4.4. Examining potential "greenwashing" behavior

The ultimate goal of corporate green innovation lies in enhancing firms' green development levels and promoting their ability to identify new growth points while undergoing green transformation.

DOI: 10.54254/2754-1169/2025.MUR22460

Therefore, beyond investigating the influence of climate risk on firms' green innovation levels, it is necessary to further examine whether such green innovation contributes to improving firms' production levels and sustainable development capabilities under the green development paradigm, thereby enhancing their green competitiveness.

The results in Table A8 indicate that when facing climate risks, firms may be more inclined to apply for green patents as a way to address policy pressures, obtain government subsidies, or enhance their corporate image, rather than to actually improve production efficiency. This kind of "strategic patent application" behavior may lead to a disconnect between the increase in patent numbers and improvements in production efficiency. Moreover, the transformation from green patents to actual productivity requires time, including the maturation of technology, equipment upgrades, and employee training. Therefore, in the short term, the growth in patent numbers may not be significantly reflected in total factor productivity.

5. Conclusions and policy recommendations

In the current context of frequent global extreme weather events and intensified climate risks, how to adapt to climate change and address climate risks has garnered widespread attention from all sectors of society. Based on this, this paper uses observational data from Chinese A-share listed companies from 2009 to 2022 to empirically examine the impact of climate risk on corporate green innovation. The results demonstrate that the higher the level of climate risk in a firm's registered location, the higher the level of green innovation by the firm. This conclusion remains valid after robustness tests, including replacing the measurement methods of key variables, changing the sample scope, and adding province and year fixed effects. Further research find that this effect was more pronounced in non-state-owned and highly polluting firms.

The mechanism analysis indicates that climate risk primarily promotes green innovation by encouraging firms to increase R&D investment and accelerate digital transformation. From the perspective of structure, climate risk mainly fosters green innovation by increasing the absolute value of a firm's R&D personnel and capital investment, while its impact on the proportion of R&D personnel and the proportion of R&D expenditure is not significant. Regarding the funding sources for R&D investment, this paper finds that both the firm's own operating income and government subsidies are important sources of increased R&D investment. This paper also finds that the green innovation achievements of firms have not yet fully translated into improvements in green production levels.

Building on the above conclusions, this paper provides the following insights:

Further improve regional climate risk assessment and response mechanisms. Governments should strengthen dynamic assessments of climate risks in different regions and formulate differentiated policy support. Particularly in high climate-risk areas, policy guidance will encourage firms to increase their green innovation investments and promote the transformation of green innovation achievements.

It should be noted that this study has some limitations. The paper measures corporate green innovation levels using only one indicator—green patent counts—without considering other measurement methods. Moreover, further research could investigate the conditions and mechanisms for translating corporate green innovation achievements into tangible outcomes.

Due to space limitations, if the tables and data included in the appendix is required, please contact the author.

References

[1] *SHI W J, WANG M L, LIU Y T. Crop yield and production responses to climate disasters in China[J]. Science of the Total Environment, 2021, 750: 141147.*

DOI: 10.54254/2754-1169/2025.MUR22460

[2] Fuhrer J, Beniston M, Fischlin A, et al. Climate risks and their impact on agriculture and forests in Switzerland[J]. Climate variability, predictability and climate risks: a European perspective, 2006: 79-102.
[3] Chen Guojin ,CHEN Lingling ,JIN Haocan ,ZHAO Xiangqin. Climate Transition Risk and Macroeconomic Policy Regulation[J]. Economic Research Journal, 2023,58(05):60-78.
[4] Chien-Chiang Lee, Chih-Wei Wang, Bui Tien Thinh, Zhi-Ting Xu. Climate risk and bank liquidity creation: International evidence[J]. International Review of Financial Analysis, Volume 82, 2022,102198,ISSN 1057-5219.
[5] Chen Y, Zhang D, Wu F, et al. Climate risks and foreign direct investment in developing countries: the role of national governance[J]. Sustainability Science, 2022, 17(5): 1723-1740.
[6] Ran Mingdong ,Zheng Yuan ,Wang Chenglong. Research on the Impact of Extreme Climate Risk on Corporate Cross-Regional Investment[J]. Chinese Journal of Management, 2024,21(11):1708-1717.
[7] Zhai Pengxiang , Lei Lei ,FAN Ying , et al. Climate policy uncertainty and the cost of corporate bond[J]. Systems Engineering-Theory & Practice , 2024, 44(11): 3520-3536.
[8] Wang Qian, Hui Yuhang. Impact of climate risks on enterprise value[J]. China Population,Resources and Environment , 2024, 34(09):22-31.
[9] Li,Q.,H. Shan,Y. Tang and V. Yao. Corporate Climate Risk: Measurements and Responses. SSRN Working Paper, 2020, No. 3508497.
[10] Burke M, Hsiang S M, Miguel E. Global non-linear effect of temperature on economic production[J]. Nature, 2015, 527(7577): 235-239.
[11] Bellprat, O., V. Guemas, F. Doblas-Reyes, and M. G. Donat. Towards Reliable Extreme Weather and Climate Event Attribution. Nature Communications, 2019, 10(1): 1–7.
[12] Zhang Shuai, Abduwalee Aibai. The Impact of Climate Extremes on Regional Financial Risks[J]. Finance and Economy, 2024, (01) : 30-40.DOI:10.19622/j.cnki.cn36-1005/f.2024.01.003.
[13] Diffenbaugh N S, Burke M. Global warming has increased global economic inequality[J]. Proceedings of the National Academy of Sciences, 2019, 116(20): 9808-9813.
[14] Yang Ping, He Kun, Yuan Ping, et al. Climate Change and Financial Risk—Views on Climate Finance Research[J]. Financial Market Research, 2021, (01):79-84.
[15] Wang Xin, Wang Ying. Research on the Green Innovation Promoted by Green Credit Policies[J]. Journal of Management World, 2021,37(06):173-188+11.DOI:10.19744 /j.cnki.11-1235/f.2021.0085.
[16] Liu Liang, Chen Liang, Zhao Xiaotao. Green Credit and Enterprise Green Innovation: The Perspective o f Industrial Chain[J]. Shanghai Journal of Economics, 2024, (11):65-78.DOI: 10.19626/j.cnki.cn31-1163/f. 2024.11.011.
[17] Peng Hongfeng ,Wan Yang ,Wang Wenhao. Could Capital Account Bidirectional Openness Motivate Enterprise's Green Innovation[J]? World Economy Studies, 2024, (11):3-17 +135.DOI:10.13516/j.cnki.wes.2024.11.007.
[18] Porter M E, Van Der Linde C. Green and competitive: Ending the stalemate[J]. Harvard Business Review, 1995, 73(5): 120–134.
[19] Wang B, Han S, Ao Y, et al. The impact of public opinion pressure on construction company green innovations: the mediating effect of leaders' environmental intention and the moderating effect of environmental regulation[J]. Frontiers in Psychology, 2022, 13: 936058.
[20] Cai Qing-feng ,Yan Wei-wei ,SHU Shao-wen. The Supply Chain Spillover of Green Innovation: From the Perspective of the Collaborative Development for Core Enterprises and Suppliers[J]. Business and Management Journal, 2024, 46(06): 43-59.DOI:10.19616/j.cnki.bmj.2024.06.003.
[21] Long H, Feng G F, Gong Q, et al. ESG performance and green innovation: An investigation based on quantile regression[J]. Business Strategy and the Environment, 2023, 32(7): 5102-5118.
[22] Tang M, Liu Y, Hu F, et al. Effect of digital transformation on enterprises' green innovation: empirical evidence from listed companies in China[J]. Energy Economics, 2023, 128: 107135.
[23] Cohen W M, Levinthal D A. Absorptive capacity: A new perspective on learning and innovation[J]. Administrative Science Quarterly, 1990, 35(1): 128-152. DOI: 10.2307/2393553.
[24] Qi Shaozhou ,Lin Shen ,Cui Jingbo. Do Environmental Rights Trading Schemes Induce Green Innovation? Evidence from Listed Firms in China[J]. Economic Research Journal, 2018, 53(12): 129–143.
[25] Du Jian, Xu Xiaoyu, Yang Yang. Does Corporate Climate Risk Affect the Cost of Equity? — Evidence from Textual Analysis with Machine Learning[J]. Chinese Review of Financial Studies, 2023, 15(03):19-46+125.
[26] XU Jia, CUI Jing-bo. Low-Carbon Cities and Firms' Green Technological Innovation[J]. China Industrial Economics, 2020, (12): 178-196.DOI:10.19581 /j.cnki.ciejo urnal.2020.12.008.
[27] JIANG Ting. Mediating Effects and Moderating Effects in Causal Inference[J]. China Industrial Economics, 2022, (05):100-120.DOI:10.19581 /j.cnki.ciejournal.2022.05.005.
[28] Zhao Chenyu, Wang Wenchun, Li Xuesong. How Does Digital Transformation Affect the Total Factor Pr oductivity of Enterprises[J]? Finance & Trade Economics, 2021, 42(07):114-129. DOI:10.19795/j.cnki.cn1 1-1166/f.20210705.001.

DOI: 10.54254/2754-1169/2025.MUR22460

[29] Zhang Bo, Yi Jia Xi. The Impact of Digital Transformation on Firms' Green Technological Innovation[J]. Statistics & Decision, 2024, 40(15):178-182. DOI:10.13546 / j.cnki.tjyjc.2024.15.031.

[30] Kwilinski A, Lyulyov O, Pimonenko T. Unlocking sustainable value through digital transformation: An examination of ESG performance[J]. Information, 2023, 14(8): 444.