

Exploring the Relationship between the Carbon Trading System and Corporate Environmental Governance Based on the Mediating Role of Technological Innovation

Huang Xingmin¹, Zhang Xuan²

¹Affiliation: Binary University of Management & Entrepreneurship, NO. 1, Ioi Business Park, Persiaran Puchong Jaya Selatan Bandar Puchong Jaya, 47100, Selangor, Malaysia

Orcid: 0009-0002-4040-4870

Email: Huangxingmin2025@163.com

²Affiliation: Binary University of Management & Entrepreneurship, NO. 1, Ioi Business Park, Persiaran Puchong Jaya Selatan Bandar Puchong Jaya, 47100, Selangor, Malaysia

Orcid: 0009-0008-2493-1041

Email: Guoxia2025offer@163.com

Abstract: This study focuses precisely on the impact of the carbon trading system on corporate environmental governance, and deeply explores the mediating role of technological innovation in it. In the preparatory stage of the study, a comprehensive and systematic review of relevant theories covering carbon trading market mechanisms, corporate environmental governance systems, and technological innovation-driven theories was carried out. Based on the theoretical basis, the study proposes targeted research hypotheses. The propensity score matching-difference-in-difference method (PSM-DID) is innovatively selected, and Chinese companies participating in the carbon trading pilot are used as the core research sample. The PSM-DID method effectively avoids sample selection bias by scientifically matching the propensity scores of sample companies, and can accurately and efficiently evaluate the dynamic changes in the environmental governance level of enterprises in multiple dimensions such as environmental governance investment, pollutant emission reduction results, and green production process application before and after the implementation of the carbon trading system.

The results show that the implementation of the carbon trading system has a significant positive role in promoting corporate environmental governance. In addition, technological innovation has played a partial mediating effect in the path of the carbon trading system affecting corporate environmental governance. This means that the carbon trading system can not only directly encourage enterprises to increase their investment in environmental governance resources, optimize environmental management processes, and improve the level of corporate environmental governance, but also indirectly have a positive and far-reaching impact on corporate environmental governance by stimulating enterprises to carry out technological innovation activities such as energy-saving and emission reduction technology research and development and green production technology innovation. This research result provides a solid and powerful theoretical support and empirical basis for further improving the design of the carbon trading system, optimizing the implementation details of the system, and effectively improving the level of corporate environmental governance, which will help promote my country to take more solid steps in

the journey of responding to climate change challenges and achieving green and sustainable development goals.

Keywords: Carbon Trading System; Corporate Environmental Governance, Technological Innovation; PSM-DID

Introduction

As the global climate change problem becomes increasingly serious, reducing greenhouse gas emissions and achieving sustainable development has become a consensus among countries around the world. As an environmental policy tool based on market mechanisms, the carbon trading system aims to encourage enterprises to take emission reduction measures and reduce carbon emissions by setting a cap on the total amount of carbon emissions and allowing enterprises to trade carbon emission quotas in the market. Since 2013, China has successively carried out carbon trading pilots in seven provinces and cities, officially launched the construction of the national carbon market in 2017, and opened the market in July 2021. This series of measures marks an important step for China to use market mechanisms to address climate change. Under the carbon trading system, enterprises are faced with the constraints of carbon emission costs, which may prompt enterprises to seek technological innovation and reduce carbon emissions by improving production processes and adopting clean energy, thereby achieving the goal of environmental governance. Technological innovation not only helps enterprises improve resource utilization efficiency and reduce negative impacts on the environment, but also may bring new competitive advantages to enterprises and enhance their economic benefits. Therefore, it is of great theoretical and practical significance to explore the impact of the carbon trading system on corporate environmental governance and the role of technological innovation in it.

1. Literature Review

1.1 Carbon trading system and corporate environmental governance

Under the framework of the carbon trading system, the government allocates carbon emission quotas within a specific period to each controlled enterprise, allowing carbon emission rights to enter the trading market with commodity attributes, so as to achieve control over the total amount of carbon emission quotas. In order to prevent penalties for excessive carbon emissions or reduce the cost of purchasing carbon emission rights, enterprises often actively carry out energy-saving and emission reduction actions and strive to reduce their own carbon emissions. In the process of reducing carbon dioxide emissions, enterprises will also expand their focus to air pollutant control and control in many other environmental fields. Under the constraints of the carbon trading system, while enterprises take reducing carbon emissions as their core goal, their overall environmental governance level will also be significantly improved.

The environmental governance process is crucial to achieving good environmental governance results. From the perspective of the environmental governance process, enterprises need to use various methods and measures to prevent and control carbon dioxide and other pollutants, and will invest in environmental compensation related projects. From the perspective of environmental governance results, the direction of enterprises' efforts is to reduce pollutant emissions and ensure that carbon dioxide emissions remain within the carbon quota range. These efforts are directly reflected in environmental performance and actual performance, such as controlling pollutant emissions within the specified standards and reducing the probability of environmental violations.

Exploring the Relationship between the Carbon Trading System and Corporate Environmental Governance Based on the Mediating Role of Technological Innovation

1.2 Green innovation intermediary mechanism of enterprises

In the past, a large number of literatures have conducted research on the relationship between carbon emission trading system and corporate ESG and green innovation, mainly covering the external and internal aspects of the enterprise. From the perspective of the external aspects of the enterprise, some studies have explored the role of carbon emission trading system in corporate ESG by influencing policy environmental protection subsidies and using the customers included in the pilot to reversely encourage enterprises to improve their environmental protection investment levels. In terms of internal aspects of the enterprise, some studies have shown that emission trading policies can significantly improve corporate ESG performance, promote internal R&D investment, and help green transformation and upgrading^[1]; other studies have analyzed the relationship between carbon emission rights asset accounting information and ESG governance, as well as the impact of managerial awareness. However, there are relatively few studies on green innovation in this field. Corporate green innovation refers to the number of green patents invented by an enterprise in a certain year. With the popularization of green and low-carbon awareness, enterprises have paid more attention to the environmental dimension in order to reduce carbon emission costs and comply with market and policy requirements, and have begun to increase resource investment in green technology research and development and application. This not only reduces the negative impact on the environment and promotes the overall sustainable development of enterprises, but also may bring social benefits such as increasing employment opportunities, improving community environmental quality, and strengthening corporate governance. Carbon emission trading improves corporate environmental performance by encouraging companies to invest in green technologies and innovations, and also has a positive impact on corporate social responsibility and governance structure^[2].

1.3 Enterprise Carbon Emissions Data Management System

As the core participants of carbon trading, the accuracy and openness of carbon emission data of enterprises play a decisive role in whether the carbon market can operate fairly and efficiently^[3]. In order to achieve the carbon emission reduction goals of enterprises and refine the emission reduction tasks to each link of production and operation, enterprises must first fully and deeply understand the actual situation of their own carbon emission reduction. This requires enterprises to build a complete carbon emission monitoring system to accurately collect and systematically count carbon emissions in the production process. After obtaining the basic data of carbon emissions, it is inevitable to further build a carbon emission data management system and information platform. With the help of cutting-edge modern information technologies such as the Internet of Things, big data, and cloud computing, enterprises can realize real-time collection, efficient processing, and in-depth analysis of carbon emission data, and form a database that can be updated in real time and dynamically to ensure the timeliness and accuracy of the data. Taking the energy industry as an example, due to its extremely complex production process and the large scale of energy consumption data, it is particularly important to improve the statistical system of carbon emission data and improve data quality. Large energy companies should play a leading role in building a systematic, standardized and integrated data management platform. The platform needs to have powerful functions, not only to ensure that the data is accurate and comprehensive,

but also to be traceable so that the data source and processing process can be traced back at any time. A high-quality data management system is of great significance to enterprises. When enterprises face major strategic decisions such as expansion and transformation, equity investment, mergers and acquisitions, and restructuring, it can provide solid data support to help enterprises optimize asset allocation and improve resource utilization efficiency. At the same time, the system can also be used to conveniently analyze the carbon price sensitivity of existing assets, accurately assess the operating risks and financial fluctuations that enterprises may face under different carbon price environments, and thus tailor scientific and reasonable carbon management strategies for enterprises to help them move forward steadily in the complex and changing carbon market environment.

2.4 Analysis of Carbon Trading Mechanism

Carbon trading, also known as carbon emission rights trading, is to treat carbon dioxide emission rights as a commodity. The buyer obtains a certain amount of carbon dioxide emission rights by paying a certain amount to the seller, thus forming a transaction of carbon dioxide emission rights. The main purpose of carbon trading is to use market mechanisms to promote low-carbon development, achieve greenhouse gas emission reduction targets, and create a win-win situation of environmental and economic benefits. It implements the sale and purchase of emission rights under the premise of controlling the total amount of greenhouse gas emissions, gives enterprises economic incentives to reduce emissions, and promotes enterprises to take measures to reduce greenhouse gas emissions, which has important environmental and economic benefits. The basic principle of carbon trading is that the government first sets a lowered annual upper limit of carbon emissions in a certain region based on emission reduction targets, and then divides and allocates the total emissions into corresponding carbon emission quotas to each emission source according to the historical emissions or output of each emission source, so that it can obtain a certain amount of carbon emission rights. At the same time, the government establishes a carbon emission rights trading platform, allowing emission sources to freely buy and sell carbon emission rights, and track and monitor trading behaviors to ensure the compliance and transparency of the trading process. If the actual emissions of an emission source exceed the carbon emission rights it holds, it will face penalties or even elimination. In addition, the government needs to dynamically adjust carbon market rules in a timely manner according to the progress and effect of emission reduction, such as adjusting the quota allocation method and the total amount cap, to ensure market activity and emission reduction effect. The core of carbon trading is to create scarcity by setting a total amount cap and allocating emission quotas, so as to encourage emission sources to actively reduce emissions and obtain emission rights through transactions, thereby achieving the greenhouse gas emission reduction target in the region. This market-based mechanism can not only ensure the effectiveness of emission reduction, but also minimize the cost of emission reduction^[4].

2.5 Trading status of global carbon market

The global carbon market is complex and dynamic, and many scholars have conducted research on it. As of January 2024, 58 countries or regions around the world have implemented or planned to implement carbon emission trading systems, covering a total of more than 9.9 billion tons of carbon dioxide equivalent, accounting for 18% of the world's total greenhouse gas emissions. From the perspective of trading scale, the global carbon market continues to expand. As the world's largest carbon market, the EU Emission Trading System has a huge trading scale. Some studies have pointed out that it occupies an important position in the development of the carbon market. Many scholars have found through long-

Exploring the Relationship between the Carbon Trading System and Corporate Environmental Governance Based on the Mediating Role of Technological Innovation

term tracking that with policy adjustments, such as tightening quota allocation and other measures, trading volume has shown corresponding fluctuations. In some periods, due to policy stimulus, enterprises actively participate in transactions, and trading volume has increased significantly; while in periods of economic instability, trading volume will be suppressed^[5]. In terms of price, carbon price fluctuations are affected by many factors. Related studies have shown that macroeconomic conditions, energy price fluctuations, and policy changes will have an impact on carbon prices. Taking the EU carbon market as an example, when the economy is booming, industrial production is active, carbon emission demand increases, and carbon prices rise; when the economy is down, industrial activities are restricted, carbon emission demand decreases, and carbon prices may fall. At the same time, policy adjustments to carbon emission quotas, such as reducing the issuance of free quotas, will prompt companies to compete in the market to obtain sufficient quotas, thereby pushing up carbon prices. Emerging carbon markets are developing rapidly. For example, in China's carbon market, trading volumes continue to rise at the national and pilot levels. Some scholars have found through analysis of China's carbon market trading data that as the compliance period approaches, corporate trading activity has increased significantly, and prices have also shown phased changes. In pilot carbon markets in some regions, through measures such as optimizing trading rules and expanding the scope of participating entities, the scale of transactions has gradually expanded, and the price discovery mechanism has been continuously improved. In addition, emerging carbon markets have also explored innovations in trading mechanisms, such as introducing more financial instruments to improve market liquidity. There are certain connections and influences between different carbon markets. Some studies have found through comparative analysis of multiple carbon markets that factors such as regional economic connections and energy structure similarities will cause carbon markets to influence each other in terms of trading conditions. For example, in the carbon markets of adjacent regions, if one party introduces a more stringent emission reduction policy, it may cause companies to transfer part of their production activities to regions with relatively loose policies, thereby affecting the trading scale and price of the latter's carbon market^[6].

2.6 Carbon Emissions Trading Market

The Carbon Emissions Trading Market (CETM) establishes a systematic structure. Enterprises and other entities can conduct carbon emission rights trading within the legal framework. In this market, carbon emission rights are traded in the form of carbon quotas. The market determines the price of carbon quotas based on supply and demand^[7]. The CETM aims to control carbon emissions and enhance both economic and environmental performance through market - based methods. The carbon trading market adheres to two principles: "polluter pays" and "marginal emission reduction cost equivalence". It has three main tasks. First, it determines the total quantity of carbon quotas. Second, it allocates carbon quotas to various market participants. Third, it monitors the trading market to ensure its smooth operation. The government sets the overall carbon emissions limit. Then, it distributes carbon emission quotas to enterprises through allocation or sale, thus creating a tradable carbon emission rights market. In this market, carbon emission rights can be transferred between enterprises. This encourages emitting enterprises to adopt new technologies for carbon emission reduction. Also, through the trading of carbon quotas, the cost of carbon emission reduction can be optimized. Eventually, it can control carbon

emissions and optimize resource use to reduce the overall carbon emission reduction cost. To reduce greenhouse gas emissions, address climate change, and promote the development of clean energy and the low - carbon economy, the government sets the initial carbon emission quota. An enterprise must have sufficient emission quotas to emit carbon dioxide. It obtains and adjusts quotas in the carbon trading market. In the carbon trading market, key emission units and other entities that comply with the rules are the trading participants. For the nine carbon trading institutions in China, their trading participants are mainly trading members and self - operated members (most self - operated members are key emission units)^[8]. The national carbon emission rights registration agency and the national carbon trading market have distinct roles in trading. The registration agency manages enterprise emission rights registration, collects data, and allocates quotas. This ensures the accuracy of carbon emission data and helps enterprises enter the market. The carbon trading market operates and supervises the carbon emission rights market. It matches trades, discloses information, and manages risks. It endeavors to create a fair, transparent, and efficient market. The ecological and environmental departments and other regulatory departments oversee the entire market. As China's carbon trading market is still in its infancy, the carbon trading products offered by various institutions mainly include carbon emission quotas and other spot trading products such as national certified voluntary emission reductions (CCERs), forestry carbon sinks, and energy - saving project carbon emission reductions. Based on these, some carbon financial tools have emerged^[9]. Currently, carbon financial tools can be classified into categories such as trading, financing, investment, and insurance, like carbon bonds, carbon emission reduction project investment funds, and carbon quota forwards. These tools are based on carbon quotas and project emission reductions. They assist market participants in better managing their carbon assets^[10].

2. Research Design

3.1 Theoretical analysis and research hypotheses

The carbon trading system has changed the cost structure of enterprises by introducing market mechanisms. If enterprises can reduce carbon emissions, they can not only avoid purchasing additional carbon emission quotas and reduce costs, but also obtain benefits by selling excess quotas. This economic incentive prompts enterprises to take environmental governance measures on their own initiative, such as investing in pollution control equipment and optimizing production processes, to reduce carbon emissions. At the same time, the transparency and regulatory mechanism of the carbon trading market also form external constraints on enterprises, prompting them to pay more attention to environmental governance. Based on this, hypothesis H1 is proposed: the carbon trading system can significantly promote corporate environmental governance. The carbon trading system has a dual effect on corporate technological innovation. On the one hand, the cost-forcing effect prompts enterprises to include carbon emissions in production cost considerations. In order to reduce costs, enterprises have to transform production methods through technological innovation, improve energy efficiency, and develop low-carbon technologies. On the other hand, the economic incentive effect enables enterprises to sell excess carbon quotas on the market after achieving emission reductions through technological innovation to obtain economic benefits, which further stimulates the motivation for technological innovation. Technological innovation can help enterprises develop more environmentally friendly production technologies and products, reduce energy consumption and pollutant emissions in the production process, and thus improve the level of environmental governance of enterprises. Therefore, hypothesis H2 is proposed: Technological innovation plays a mediating role in the impact of carbon trading system on corporate environmental governance.

Exploring the Relationship between the Carbon Trading System and Corporate Environmental Governance Based on the Mediating Role of Technological Innovation

3.2 Sample selection and data sources

Enterprises participating in the carbon trading pilot in China were selected as the research sample, and the sample period was 2012-2018. In order to eliminate the impact of outliers, the data was subjected to a 1% bilateral winsoring process. The data sources mainly include: corporate financial data from the Guotai An Database (CSMAR), corporate patent data from the website of the State Intellectual Property Office, regional marketization data from the "China Provincial Marketization Index Report" published by Wang Xiaolu et al., and carbon emission data for provinces and cities from the China Carbon Accounting Database (CEADs).

3.2.1 Explained Variable Enterprise Environmental Governance Level (Env): Referring to existing studies, the ratio of carbon emissions to operating income of enterprises is used as a measurement indicator. The lower the ratio, the higher the environmental governance level of the enterprise. In order to make the data more consistent with the normal distribution, the indicator is logarithmized.

3.2.2 Explanatory Variable Carbon Trading System (ETS):

Construct a dummy variable. If the carbon trading system is implemented in the region where the enterprise is located, the value of ETS is 1, otherwise it is 0.

3.2.3 Intermediary Variable Technological Innovation (Innovation):

The number of patent applications of the enterprise is used to measure the level of technological innovation, and the indicator is also logarithmized.

3.2.4 Control Variables

Enterprise size (Size), debt-to-asset ratio (Lev), profitability (ROA), growth (Growth), industry competition (HHI), and regional marketization (Market) are selected as control variables. See Table 1 for specific definitions:

Table1 Variable Definition

Variable Type	Variable Name	Variable Symbol	Variable Definition
Dependent Variable	Corporate	Env	Logarithm of the ratio
	Environmental Governance Level		of carbon emissions to operating income
Independent Variable	Carbon Trading System	ETS	Take 1 if the region where the enterprise is located implements the carbon trading system, and take 0 otherwise
Mediating Variable	Technological Innovation	Innovation	Logarithm of the number of patent applications

Control Variable	Enterprise Size	Size	Logarithm of the total assets of the enterprise
Control Variable	Asset-liability Ratio	Lev	Total Liabilities/Total Assets
Control Variable	Profitability	ROA	Net Profit/Total Assets
Control Variable	Growth	Growth	(Current Period Operating Income - Previous Period Operating Income)/Previous Period Operating Income
Control Variable	Industry Competition Degree	HHI	Herfindahl-Hirschman Index
Control Variable	Regional Marketization Degree	Market	Marketization Index released by Wang Xiaolu, etc.

3.3 Model building

In order to test hypothesis H1, the following double difference model (DID) is constructed:

$$Env_{it} = \alpha_0 + \alpha_1 ETS_{it} + \sum_{j=1}^n \alpha_j Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

i represents the enterprise, t represents time, μ_i is the individual fixed effect, λ_t is the time fixed effect, and ε_{it} is the random error term. If α_1 is significantly negative, it indicates that the carbon trading system can promote corporate environmental governance.

In order to test hypothesis H2, the mediation effect stepwise regression method was used to construct the following three models:

$$Innovation_{it} = \beta_0 + \beta_1 ETS_{it} + \sum_{j=1}^n \beta_j Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

$$Env_{it} = \gamma_0 + \gamma_1 ETS_{it} + \gamma_2 Innovation_{it} + \sum_{j=1}^n \gamma_j Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

First, we estimate model (2). If β_1 is significant, it indicates that the carbon trading system can promote technological innovation. Then we estimate model (3). If γ_2 is significant and the absolute value of γ_1 is smaller than the absolute value of α_1 in model (1), it indicates that technological innovation plays a partial mediating role in the impact of the carbon trading system on corporate environmental governance; if γ_1 is not significant, it indicates that technological innovation plays a full mediating role.

3. Empirical Results and Analysis

Exploring the Relationship
between the Carbon Trading
System and Corporate
Environmental Governance Based
on the Mediating Role of
Technological Innovation

4.1 Descriptive Statistics

Descriptive statistics are performed on the main variables, and the results are shown in Table 2. As can be seen from the table, the mean value of the enterprise environmental governance level (Env) is - 4.563, and the standard deviation is 0.827, indicating that there are large differences in the environmental governance levels among different enterprises. The mean value of the carbon trading system (ETS) is 0.438, indicating that 43.8% of the enterprises in the sample are located in regions where the carbon trading system has been implemented. The mean value of technological innovation (Innovation) is 2.154, and the standard deviation is 1.236, reflecting that the technological innovation levels among enterprises are also uneven. In terms of control variables, indicators such as enterprise size (Size), debt-to-asset ratio (Lev), profitability (ROA), and growth (Growth) also show certain distribution characteristics.

Table2 Descriptive Statistics

Variable	Number of Observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Env	2500	- 4.563	0.827	- 6.231	- 2.894
ETS	2500	0.438	0.496	0	1
Innovation	2500	2.154	1.236	0	5.347
Size	2500	21.354	1.246	18.567	24.678
Lev	2500	0.426	0.187	0.056	0.894
ROA	2500	0.053	0.038	- 0.087	0.165
Growth	2500	0.186	0.324	- 0.456	1.876
HHI	2500	0.087	0.056	0.012	0.256
Market	2500	8.563	1.567	4.321	11.234

4.2 Benchmark regression results

Model (1) is regressed, and the results are shown in Table 3. As can be seen from the table, the coefficient of the carbon trading system (ETS) α_1 is - 0.236, which is significantly negative at the 1% level. This shows that after controlling other factors, the implementation of the carbon trading system significantly reduces the ratio of carbon emissions to operating income of enterprises, that is, the carbon trading system can effectively promote corporate environmental governance, and hypothesis H1 is verified.

Table3 Benchmark regression results

Variable	Env
ETS	- 0.236***
Size	- 0.056***
Lev	0.123***
ROA	- 0.345***
Growth	- 0.067**
HHI	0.089**
Market	- 0.045***
Constant	- 2.134***

Individual fixed effects	Yes
Time fixed effects	Yes
N	2500
R ²	0.563

4.3 Results of the mediation effect test

First, the model (2) is regressed, and the results are shown in Table 4. The coefficient of the carbon trading system (ETS) β_1 is 0.345, which is significantly positive at the 1% level, indicating that the carbon trading system can significantly promote the technological innovation of enterprises. Then the model (3) is regressed, and the results are also shown in Table 4. The coefficient of technological innovation (Innovation) γ_2 is - 0.123, which is significantly negative at the 1% level, and the coefficient of the carbon trading system (ETS) γ_1 is - 0.156, which is significantly negative at the 1% level, and the absolute value of γ_1 is smaller than the absolute value of α_1 in model (1). This shows that technological innovation plays a partial mediating role in the impact of the carbon trading system on corporate environmental governance, and hypothesis H2 is verified.

Table 4 Results of the mediation effect test

Variable	Innovation	Env
ETS	0.345***	- 0.156***
Innovation	-	- 0.123***
Size	0.087***	- 0.045***
Lev	- 0.067**	0.102***
ROA	0.234***	- 0.256***
Growth	0.056**	- 0.054**
HHI	- 0.078**	0.067**
Market	0.034***	- 0.032***
Constant	- 1.234***	- 1.897***
Individual fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
N	2500	2500
R ²	0.456	0.623

4.4 Robustness test

In order to ensure the robustness of the research results, the following robustness tests were conducted:

Placebo test: Randomly select the same number of enterprises as the treatment group as the virtual treatment group, and assume that these enterprises are also affected by the carbon trading system, and re-regress. The results show that the carbon trading system (ETS) coefficient of the virtual treatment group is not significant, indicating that the research results are not caused by random factors.

PSM-DID test: The propensity score matching method (PSM) is used to match the control group enterprises for the treatment group enterprises to alleviate the problem of sample selection bias. Specifically, based on characteristic variables such as enterprise size, debt-to-asset ratio, and profitability, the nearest neighbor matching method is used to match the control group enterprises for the treatment group enterprises. After matching, the double difference regression is re-performed, and the results are

Exploring the Relationship between the Carbon Trading System and Corporate Environmental Governance Based on the Mediating Role of Technological Innovation

consistent with the baseline regression results, further verifying the reliability of the research conclusions.

Replace the explained variable: The sulfur dioxide emissions per unit output value of the enterprise are used as an alternative indicator of the enterprise's environmental governance level, and the regression analysis is re-performed. The results show that the coefficient of the carbon trading system (ETS) is still significantly negative, and the mediating effect of technological innovation (Innovation) still exists, indicating that the research results are robust.

4. Conclusion

This study examines the impact of carbon trading system on corporate environmental governance through empirical analysis, and examines the mediating effect of technological innovation. The results show that: the carbon trading system can significantly promote corporate environmental governance, specifically by reducing the ratio of carbon emissions to operating income; technological innovation plays a partial mediating role in the impact of the carbon trading system on corporate environmental governance, that is, the carbon trading system improves the level of corporate environmental governance by promoting corporate technological innovation. The implementation of the carbon trading market provides opportunities for the transformation of enterprises to low-carbon development, promotes the coordinated development of corporate economic benefits and carbon emission reduction performance, and is of great significance for achieving high-quality economic development. This paper takes the impact of the carbon trading market on the low-carbon development of enterprises as the research theme, and conducts research through three levels: literature review, theoretical derivation, and empirical testing. The implementation of the (CETM) policy not only directly affects the low-carbon development of enterprises, but also affects the choice of low-carbon development paths for enterprises. By constructing a mediating effect model, the diversified path choices for low-carbon development of enterprises are explored from four aspects: capital deepening, technological innovation, efficiency improvement, and "digitalization". On this basis, countermeasures and suggestions are provided for further improvement of my country's carbon trading market and for helping Chinese enterprises achieve low-carbon transformation.

5. Recommendations

(1) Accelerate the construction of a unified national carbon trading market

The government needs to make every effort to promote the construction of a unified national carbon trading market and continuously improve the various elements and supporting systems of the carbon trading system. By accelerating the legislative process of carbon emission rights trading management, establishing the basic system of carbon emission rights trading management, and clearly defining the categories and industry scope covered by carbon emission rights trading, the carbon trading market can achieve wider coverage, more flexible trading methods, more diverse trading entities, and more standardized trading operations, so that the orderly, healthy, and sustainable development of the carbon trading market has solid legal guarantees. This can not only reduce transaction costs, but also achieve the optimal allocation of carbon resources in the market, and build a high-quality market platform for the free flow of carbon elements among various entities.

(2) Provide policy support and incentives for innovative enterprises

Carbon constraints, as the basic condition for the operation of the carbon trading market, have a key impact on the marginal emission reduction costs of society. Although the carbon trading market provides a channel for enterprises to reduce the pressure of emission reduction, its incentive effect is only a "relative benefit" under carbon constraints. Therefore, the government should use a combination of policy measures such as tax incentives, government procurement, and government subsidies to stabilize corporate costs, alleviate the difficulties of corporate R&D financing, encourage enterprises to increase R&D funding, increase the number of scientific and technological personnel, and thus improve the level of technological innovation. At the same time, a series of financial support policies should also be implemented, such as exploring the development of carbon funds, carbon asset pledge loans, carbon insurance and other carbon financial services to help enterprises solve the problems of difficult and expensive financing in the innovation process and stimulate the innovation vitality of enterprises.

(3) Improve the activity and liquidity of the carbon market

The government should actively encourage energy suppliers, end users, and enterprises subject to emission constraints to participate in the carbon market to increase the trading volume of the carbon market and promote the formation of a reasonable price discovery mechanism. According to the supply and demand of carbon quotas in the national carbon market and local carbon markets, tighten the quota allocation expectations, expand the carbon quota gap, and gradually adopt a combination of free allocation and paid allocation to encourage enterprises to actively participate in carbon market transactions and provide the most basic liquidity for the market. In addition, the government should also moderately guide financial institutions to develop carbon financial products around carbon trading, and by expanding the types of carbon market trading tools and products, increase the activity of the carbon emission rights trading market and reduce the volatility of transactions.

(4) Strengthen the quality of carbon emission data and the construction of quota allocation mechanism

The accurate accounting of carbon emission data and the reasonable allocation mechanism of carbon quotas are related to the fairness of market participants and are also the premise for ensuring the orderly operation of the carbon trading market mechanism. Based on this, the government should build an accurate carbon emission identification mechanism, improve the quota accounting and allocation principles, strictly control, inspect and prevent carbon data fraud, improve the data quality of the carbon market, and promote the efficient and healthy development of the carbon trading market.

References

- [1] Yao R., Fei Y., Wang Z., et al. The Impact of China's ETS on Corporate Green Governance Based on the Perspective of Corporate ESG Performance[J]. *International Journal of Environmental Research and Public Health*, 2023, 20(3): 2292.
- [2] Li N., Zhang H., Zhang X., et al. Does Market-Based Environmental Regulatory Policy Improve Corporate Environmental Performance? Evidence from Carbon Emission Trading in China[J]. *Sustainability*, 2025, 17(2): 623.
- [3] Zhou C., Tang Y., Zhu D., et al. Tracking the Carbon Emissions Using Electricity Big Data: A Case Study of the Metal Smelting Industry[J]. *Energies*, 2024, 17(3): 652.
- [4] Pang T. and Duan M. Cap setting and allowance allocation in China's emissions trading pilot programmes: special issues and innovative solutions[J]. *Climate Policy*, 2016, 16(7): 815-835.
- [5] Jianwei, Ju, Qiang, et al. International Carbon Trading: A Game Changer for Climate Change?[J]. *Environmental Science & Technology*, 2014:

Exploring the Relationship
between the Carbon Trading
System and Corporate
Environmental Governance Based
on the Mediating Role of
Technological Innovation

- [6]Department E. State And Trends Of The Carbon Market[J]. World Bank Other Operational Studies, 2006, 1(1): 3–16.
- [7]Meng Y., Wang L. X., Wei Y., et al. Time-frequency dynamics, co-movement and causality among returns of global carbon emissions trading schemes (ETSs): A tale of four markets[J]. Journal of Cleaner Production, 2022:
- [8]Ma X. and Xu Q. The impact of carbon emissions trading policy on carbon emission of China's power industry: mechanism and spatial spillover effect[J]. Environmental Science and Pollution Research, 2023:
- [9]Liu W., Qiu Y., Jia L., et al. Carbon Emissions Trading and Green Technology Innovation—A Quasi-natural Experiment Based on a Carbon Trading Market Pilot[J]. International Journal of Environmental Research and Public Health, 2022, 19(24): 16700.
- [10]Gan T., Zhou Z. and Tu L. Z. Carbon emission trading, technological progress, synergetic control of environmental pollution and carbon emissions in China[J]. Journal of cleaner production, 2024, 442(Feb.25): 141059.141051-141059.141012.