DOI: 10.2478/eces-2023-0027 ECOL CHEM ENG S. 2023;30(2):259-266

Jing-Xuan ZHAO[1,2]

AN EMPIRICAL STUDY ON EMISSIONS TRADING INFLUENCE FOR THE ENTERPRISE ENVIRONMENTAL RESPONSIBILITY

Abstract: The primary objective of this paper is to address the inherent biases in the calculation of carbon emissions trading (CET) and foster the development of green innovation. By employing panel data from carbon emission trading pilots, the spatial Durbin model (SDID) is applied to assess the impact of CET on corporate environmental responsibility. By integrating CET and corporate environmental responsibility within a unified framework, this paper presents a novel analysis of the influence of environmental regulations on corporate environmental responsibility at the micro-level. Additionally, this study examines the spatial spillover effect of CET, thereby rectifying estimation biases. The model validation results indicate statistical significance below the 1 % level. The findings of this research reveal that it analyses the specific channels through which CET influences corporate environmental responsibility, providing insights that address the limitations of previous studies in mechanism analysis.

Keywords: CET, environmental responsibility, SDID, mechanism analysis

Introduction

In the era of knowledge economy, many countries have begun to implement innovation-driven strategies to ensure the sustainable development of their economy, ecology, and environment. Eminent scholars have underscored the robust interconnection between technological innovation and sustainable development, emphasising its substantial potential to enhance carbon emission efficiency, energy conservation, and carbon reduction to a considerable degree. Since the industrial Revolution, the industrial pollution and environmental pollution caused by the growing industrial activities have been the topic that troubles all mankind. To maintain the living environment of human beings, the topic of industrial pollution control has risen, followed by various international environmental conferences and the birth of environmental laws and regulations in various countries. During the seventy-fifth session of the United Nations General Assembly in September 2020, China expressed its dedication to bolstering efforts in carbon emission control through the formulation of more robust environmental protection policies and measures. To promote the advancement of China's green economy and curtail carbon emissions from domestic enterprises, the country has launched a pilot program for trading carbon emission rights. From 2013 to 2014, seven domestic carbon emission rights pilot exchanges began operation. In 2017, plans for a national carbon trading market were approved by The State Council. In 2021, the Interim Regulations on the Administration of Carbon Emission

[1] Business School, Hohai University, Nanjing Jiangsu 211100 China
[2] Business School, Jiangsu Second Normal University, Nanjing Jiangsu 211200 China. ORCID: 0009-0001-4043-1230, email: zhaojxuan1122@jssnu.edu.cn

Trading, CET (Draft Amendment) was released, and in the same year, the national CET market was officially launched and began trading. How to develop new energy economy, reflect China’s response to climate change, and take the green road of sustainable development are the main difficulties for China to achieve this goal, and promoting ESG is an important tool to promote the high-quality development of China’s economy. At present, Enterprise Strategy Group (ESG) has gradually become an important indicator for enterprises and governments to measure their own sustainable development ability. On the whole, the environmental dimension of ESG focuses more on the environmental protection, emission reduction, recycling and reuse of enterprises, as well as the improvement of the environmental benefits of consumers and stakeholders. It also includes whether enterprises formulate relevant policies and plans for the protection of environmental resources, encourage enterprises to carry out business activities with positive environmental benefits, and fulfil environmental responsibilities. Low-carbon economy, as a hot topic, has been concerned. How to combine low-carbon economy with enterprise development has become a key research topic in academic circles. The low-carbon economy also means that enterprises in various industries still need to change their traditional business models and development strategies. In the new development strategy, there is a lot of information that needs to be disclosed for investors and stakeholders to understand, among which the disclosure of environmental accounting information is very important, which puts forward new requirements for enterprises’ awareness of environmental responsibility.

A plethora of policy tools exist to regulate carbon emissions, including the compulsory disclosure of environmental information by high-polluting enterprises. However, when compared to mandatory administrative control, which often lacks flexibility and long-term incentives, the most market-oriented and inherently motivated approach is the implementation of carbon emissions trading. The implementation of a trading mechanism can serve as an incentive for enterprises to adapt their production activities, boost investments and proactively take on environmental responsibilities. This is achieved through the allocation of carbon emission rights quotas and imposing limitations on carbon emissions. Advanced economies like the European Union recognised the potential of carbon trading markets early on, with the establishment of the European Union Emission Trading Scheme (EUETS) as far back as 2002. Over time, the EUETS has evolved into the largest cross-border carbon emissions trading system, encompassing 24 countries and over 12,000 industrial enterprises.

It is urged to promote industrial enterprises, especially high-carbon emission enterprises, to take the initiative to participate in carbon emission reduction actions, and to fulfil the social responsibility of protecting the environment. Has CET effectively avoided the "tragedy of the commons" of corporate carbon emissions? Can this external market-oriented environmental regulation measure induce spatial spillover effects? Above analysis has important practical and policy significance for the efficient construction of the just-launched national CET market. The innovations are mainly reflected as follows:

(1) This paper incorporates CET and enterprise environmental responsibility into unified framework, and innovatively reveals the impact of environmental regulation on enterprise environmental responsibility.
(2) This paper analyses the specific channels through which CET affects enterprise environmental responsibility based on investment paths, making up for the lack of mechanism analysis in existing research.

Literature review

The EUETS stands as the most extensive cap-and-trade program implemented to date. Notably, it has witnessed a 10 % rise in patents related to low-carbon technologies compared to the baseline year of 2005, indicating a notable advancement in innovation. Moreover, the scheme has shown no significant evidence of crowding effects, further highlighting its effectiveness. In 2013, a new phase of the EU ETS commenced, wherein the allocation of allowances primarily occurs through auction bidding, marking a shift in the approach to allocation mechanisms. Wu [1] and Wu et al. [2] put forth the notion of sustainable green development and green university, drawing pertinent conclusions from their research. Xu et al. [3] discussed the path for carbon trading policies to promote the development of low-carbon technologies through synthetic control methods, and carbon trading market could become an important driving force through the synergistic effect with regional industrial structure upgrading. Guo et al. [4] discussed the impact of benchmarking method and historical method on enterprises' green technology innovation in free distribution. Zhu et al. [5] believed that the structure of quota allocation has different degrees of influence on green technology innovation. Enterprises that utilise scale allocation have significantly more low-carbon innovation than enterprises that utilise proportional allocation, and enterprises based on proportional allocation have significantly higher innovation ability. In their study, Lee et al. [6] utilised the low-carbon city pilot program as a quasi-natural experiment. They collected data from Shanghai and Shenzhen A-share listed enterprises spanning from 2008 to 2019, along with urban panel data associated with the cities where these enterprises were located. Employing the progressive differential method, they examined the effects of the national low-carbon strategy on the total factor productivity of these enterprises. The findings of the research indicate that the implementation of the low-carbon strategy has had a significant positive impact on the overall productivity of local listed enterprises. This, in turn, has contributed to economic growth, ultimately leading to a "win-win" situation for all involved parties.

Ke et al. [7] utilised data envelopment analysis to assess the potential impact of CET policies on carbon dioxide emissions and Gross Domestic Product (GDP) output. Rui et al. [8] conducted a study using Shanghai, one of the seven pilot cities in China, as an example. They applied the Computable General Equilibrium (CGE) model to evaluate the economic impact and concluded that the carbon trading market mechanism could reduce the GDP loss associated with carbon emission reduction. Li et al. [9] employed a STIRPAT-embedded dynamic CGE model to evaluate the simulation effect on China's economy, energy, and households, and further assessed the trial effect of the CET market.

Fang et al. [10] believed that for carbon market trading, excessive government control and excessively high carbon trading price not only fail to play a substantial role in carbon emission reduction, but also have the opposite impact as expected. Based on existing literature studies, Li et al. [11] analysed and concluded that carbon trading mechanism, as a market-incentive environmental regulation policy, became a commodity through the definition of carbon dioxide emission rights, so that entities with higher emission control costs and entities with lower emission control costs could trade through the market, which had a significant and continuous promoting effect on carbon emission reduction. Chai et al. [12] held that the CET mechanism had a more obvious promotion effect on remanufacturing enterprises, which could increase their investment in low-carbon technology and improve the level of technological innovation. Yue et al. [13] conducted a study on the influence of carbon trading pilot policies on the transformation and upgrading of China's manufacturing industry. The findings indicated that the carbon trading mechanism did not significantly impact the productivity of enterprises in the six heavily polluting industries in China. On the other hand, Andreas et al. [14] examined the emissions trading scheme and its impact on economic benefits. Their research concluded that the trading scheme had a positive influence on the economic performance of participating enterprises.

Based on the above review of existing literature, CET not only has an important impact on the realisation of a virtuous cycle of economic and environmental development, but also has great significance for the development decision-making of micro-enterprises. Therefore, based on the existing literature, this paper links CET with corporate environmental responsibility, analyses the impact of CET on the environmental responsibility of surrounding companies, which tries to make marginal contributions to the research of China's green technology innovation, urban economic development, carbon emission reduction effect, etc., and put forward constructive policy suggestions for China's economic development.

Model design

Data sources

This study took the formal implementation of the CET policy in seven pilot regions in 2013 as the impact point, selected all the A-share listed companies in Shanghai and Shenzhen as the initial samples, selected 2008-2019 as the sample interval, and processed the selected samples accordingly. A total of 1258 enterprises were selected as research samples. The data in this paper are from CSMAR and CNRDS databases.

Variable definition

Dependent variable. Corporate environmental responsibility reflects the impact of an enterprise on the environment in its production process. For the variable of environmental information disclosure, foreign research generally adopts the method of measuring it with the information disclosure index released by authoritative institutions. However, at present, there is no widely recognised authoritative research institution in China that can release such an index, so this method is not widely accepted.

Table 1

The description of control variable

Name	Symbol	Measure method
Enterprise size	*Size*	Total assets in logarithmic form
Return on assets	*ROA*	The ratio of net profit to the average balance of total assets
Environmental regulation	*ENVI*	Total investment in industrial pollution control where the enterprise belongs
Nature of property right	*SOE*	State-owned enterprise is 1, or is 0
Number of executives	*EX*	The total number of executives
Ownership concentration	*TOP*	Number of shares held by the largest shareholder/total number of shares

Therefore, considering the existing literature and the research theme, as well as the availability of research data, this paper constructs the Corporate Environmental Information

Disclosure Index. This index is derived from the collection of annual reports and other environmental information reports from selected companies, and is utilised as a proxy variable to measure corporate social responsibility.

Control variables. In this paper, the following enterprise-level variables are chosen as control variables, following the method used in existing literature. The specific definitions of these variables are presented in Table 1.

Research methods

SDID introduces two dummy variables and their cross terms into the model, and judges the degree of influence of the event by the coefficient of the cross terms. This paper examines the impact on corporate environmental responsibility after the implementation of the CET pilot policy, which exists in two dimensions: one dimension is the difference between the environmental responsibility of enterprises that implement the CET policy and those that do not; Another dimension is the difference between corporate environmental responsibility. To assess the implementation effectiveness of the CET policy more accurately, the differential method is employed. Additionally, to further analyse its spatial spillover effect, this paper establishes the following measurement model, incorporating a spatial weight matrix:

$$CER_{ijt} = \beta_0 + \beta_1 T1_{it} \times T2_t + \beta_2 W \cdot T1_{it} \times T2_t + \beta_3 X + +\gamma_i + \eta_j + \varepsilon_{ijt} \tag{1}$$

where CER_{ijt} is the explained variable, is the enterprise environmental responsibility variable calculated above; $T1 \times T2$ is the core explanatory variable, which is the cross-multiplication term of time dummy variable and group processing variable. W is the spatial weight matrix, which is used to analyse the spatial spillover effect of carbon emission rights trading. X is the control variable set. γ_i and η_j represent the regional fixed effect and individual fixed effect, respectively, and ε_{ijt} is the random error term. β represents the conditioning coefficient of the model, and t represents the year, i represents the region, and j represents the individual.

Empirical results

Robustness test

Replace the dependent variable. The benchmark regression results of this paper measure corporate environmental responsibility through the establishment of an indicator evaluation system. In order to further verify that the research conclusions of this paper are not affected by the selection of indicators, this paper conducts a robustness test by replacing measurement indicators. By using the rating data provided by professional rating agencies in the society (such as Runling Global Responsibility Rating Agency), the quality of corporate environmental information disclosure is measured and tested for robustness.

Counterfactual testing. In this paper, the robustness of the datum regression results is tested by constructing regional counterfactuals. According to the GDP data of Chinese provinces in 2019, the provincial capitals of the top provinces - Guangdong, Jiangsu, Zhejiang, Shandong, Henan and other provinces - and the provincial capitals of the bottom provinces - Qinghai Province, Ningxia Autonomous Region, Hainan Province, Gansu, Jilin Province, Xinjiang Autonomous Region, Heilongjiang Province and other provincial capitals were selected as the CET policy intervention group. According to the regression estimation results of the samples composed of counterfactual construction, the regression coefficients of CET policies fail to pass the significance test, indicating that the CET mechanism has no significant impact on the corporate environmental responsibility of the pilot cities of the counterfactual hypothesis constructed in this paper, no matter the developed provinces or less developed provinces or cities as the treatment group. This further verifies that the level of corporate environmental responsibility of the cities in the control group will not be affected by the implementation of CET policies in the pilot provinces and cities.

The heterogeneity analysis

Heterogeneity analysis of ownership attributes: Model 1, presented in Table 2, represents the empirical results for the state-owned enterprise group, while Model 2 represents the results for the non-state-owned enterprise group. Both models show significantly positive coefficients for the independent variable. Notably, the coefficient for the non-state-owned enterprise group is significantly larger than that for the state-owned enterprise group. This suggests that non-state-owned enterprises, due to their flexibility in adjusting production activities and quickly adapting to market changes.

Heterogeneity analysis of regional environmental regulation: Model 3 and Model 4 in Table 2 depict the empirical results for the low environmental regulation degree group and the high environmental regulation degree group, respectively. The coefficient for the high environmental regulation degree group is significantly larger than that for the low environmental regulation degree group. This outcome can be attributed to the fact that regions with stringent environmental regulations have a higher awareness of environmental protection. Consequently, they are more proactive in enhancing their environmental responsibilities following the implementation of the CET.

Table 2

The heterogeneity analysis results

Variables	Ownership attribute		Environmental regulation	
	Model 1	**Model 2**	**Model 3**	**Model 4**
$T1 \times T2$	1.2069^{***} (3.69)	1.7095^{***} (3.98)	1.3071^{***} (3.37)	1.9877^{***} (4.89)
$W \cdot T1 \times T2$	0.3022^{**} (2.10)	0.4892^{**} (2.38)	0.3022^{*} (1.89)	0.6309^{**} (2.49)
Adjust R^2	0.3799	0.4145	0.3648	0.3089

Note: ***, ***, * indicate significant at the 1 %, 5 % and 10 % statistical levels, and R^2 represents the fit coefficient. The number in brackets indicates the statistical test value

Mechanism analysis

In order to foster ecologically advantageous products and enhance measures for waste reduction, it is imperative for companies to engage in environmental investments. Consequently, this manuscript primarily concentrates on scrutinising the trajectory centred on corporate environmental preservation investment (*Invest*). The objective is to assess whether the implementation of the CET engenders an elevation in corporate environmental preservation investment, subsequently influencing the enterprise's commitment to environmental responsibility. The findings are displayed in Table 3.

Model 1 delves into the influence of the CET on corporate environmental investment, while Model 2 investigates the impact of corporate environmental investment on enterprise environmental responsibility. Model 1 exhibits a significantly positive value with a level of significance at 1 %, indicating that the CET has indeed spurred an upsurge in enterprises' investment in environmental protection. Furthermore, the effect of the CET on the environmental investment of companies in the surrounding regions is also significantly positive.

Moreover, the outcomes in Model 2 unveil that corporate investment in environmental preservation exerts a noteworthy promotional impact on enterprise environmental responsibility. Evidently, the comprehensive implementation of the CET possesses the ability to stimulate companies to seamlessly integrate environmental preservation investment into their routine business operations, thereby profoundly embedding environmental consciousness into the fabric of corporate culture.

Table 3

The mechanism analysis results

Variables	**Model 1**	**Model 2**
$T1 \times T2$	0.8609^{***} (2.73)	
$W \cdot T1 \times T2$	0.1063^{*} (1.92)	
Invest		0.5503^{***} (8.47)
Adjust R^2	0.2474	0.5028

Conclusion

Based on the corporate sample data from 2008 to 2019, the heterogeneous impact of CET on enterprises of different nature and different external environmental regulations is discussed. The primary conclusions are as follows: Firstly, the CET exhibits a notable capability to substantially enhance enterprise environmental responsibility within the local and perimeter regions, with its impact progressively strengthening over the years. Moreover, the principal mechanism lies in the augmentation of corporate investment in environmental preservation.

Based on the aforementioned conclusions, this study proposes the following optimisation measures for the CET. Firstly, governments at all levels can guide carbon trading-covered enterprises to augment their environmental investments by offering subsidies and establishing dedicated funds. Secondly, the role of carbon trading in enhancing the level of environmental responsibility among covered companies demonstrates a gradual increase over time. Therefore, carbon trading market should prioritise policy reform when formulating and refining operational rules, particularly emphasising policy robustness within the initial three years. Furthermore, the government ought to intensify the dissemination of low-carbon concepts. For instance, utilising the carbon market platform to elevate the environmental responsibility awareness of enterprises. Lastly, carbon trading policies can be synergistically implemented with other environmental regulatory mechanisms, focusing on the regulatory influence of environmental regulations on the impacts of carbon trading policies. The government can stimulate carbon activity by providing tax incentives to companies actively engaging in carbon emission reduction.

References

[1] Wu CH. An empirical study on discussion and evaluation of green university. Ecol Chem Eng S. 2021;28(1):75-87. DOI: 10.2478/eces-2021-0007.

[2] Wu CH, Tsai SB, Liu W, Shao XF, Sun R, Wacławek M. Eco-technology and eco-innovation for green sustainable growth. Ecol Chem Eng S. 2021;28(1):7-10. DOI: 10.2478/eces-2021-0001.

[3] Xu T, Cheng C, Ren F, Zhang WW. Optimal scheduling of integrated energy systems considering carbon trading. J Phys: Conf Ser. 2022;2395(1). DOI: 10.1088/1742-6596/2395/1/012053.

[4] Guo HBO, Lu MT, Ding LL. The effect of consumer sentiment on manufacturers' green technology innovation: A RDEU evolutionary game model. Sustainability. 2022;15(1). DOI: 10.3390/SU15010706.

[5] Zhu J, Fan Y, Deng X. Low-carbon innovation induced by emissions trading in China. Nature Commun. 2019;10(1):1-8. DOI: 10.1016/j.omega.2015.09.011.

[6] Lee C, Feng Y, Peng DY. A green path towards sustainable development: The impact of low-carbon city pilot on energy transition. Energy Economics. 2022; 115. DOI: 10.1016/J.ENECO.2022.106343.

[7] Ke W, Yi MY, Huang ZM. Potential gains from carbon emissions trading in China: A DEA based estimation on abatement cost savings. Omega. 2016;63:48-59. DOI: 10.1016/j.omega.2015.09.011.

[8] Rui W, Han CD, Yong G. Achieving China's INDC through carbon cap-and-trade: Insights from Shanghai. Appl Energy. 2016;184:1114-22. DOI：10.1016/j.apenergy.2016.06.011.

[9] Li W, Lu C, Ding Y, Zhang YW. The impacts of policy mix for resolving overcapacity in heavy chemical industry and operating national carbon emission trading market in China. Appl Energy. 2017;204:509-24. DOI: 10.1016/j.apenergy.2017.07.017.

[10] Fang GC, Tian LX, Liu MH, Fu M, Sun M. How to optimize the development of carbon trading in China - Enlightenment from evolution rules of the EU carbon price. Appl Energy. 2018; 211:1039-49. DOI: 10.1016/j.apenergy.2017.12.001.

[11] Li H, Li R, Shang M, Liu Y, Su DD. Cooperative decisions of competitive supply chains considering carbon trading mechanism. Int J Low-Carbon Technologies. 2021;17:102-17. DOI: 10.1093/IJLCT/CTAB085.

[12] Chai QF, Xiao ZD, Lai KH, Zhou GH. Can carbon cap and trade mechanism be beneficial for remanufacturing? Int J Prod Economics. 2018;203:311-21. DOI: 10.1016/j.ijpe.2018.07.004.

[13] Yue D, Nan L, Gu RG. Can China's carbon emissions trading rights mechanism transform its manufacturing industry? Based on the perspective of enterprise behavior. Sustainability. 2018;10(7):22-31. DOI: 10.3390/su10072421.

[14] Andreas L, Benjamin JL, Shunsuke M. The impacts of the EU ETS on efficiency and economic performance - An empirical analysis for German manufacturing firms. Resource Energy Economics. 2018;56:71-95. DOI: 10.1016/j.reseneeco.2018.03.001.