

Research on Green Innovation Capacity Based on Carbon Emission Trading System

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Abstract: Realizing energy conservation and emission reduction, promoting green development, and realizing the harmonious coexistence of human and nature are the major themes of today's social and economic development and corporate environmental management. This project intends to select China's most representative carbon trading system as the research object, and empirically examine the effect and mechanism of carbon trading system on the enhancement of enterprises' green innovation ability by establishing a double-difference model and adopting the panel data of A-share listed companies in Shanghai and Shenzhen during the period of 2007-2021. The results of the study show that: (1) the implementation of the carbon emissions trading policy effectively promotes the green innovation behavior of enterprises; (2) in the heterogeneity analysis, the policy has a more significant impact on the green innovation of the enterprises in the eastern region, state-owned enterprises, and enterprises in high-technology industries; (3) in the process of carbon emissions piloting, the R&D investment of the enterprises plays the role of policy substitution for the green innovation, and the public's concern for the environmental issues degree has a positive moderating effect on enterprises' green innovation. This study reveals the influence mechanism of carbon emissions trading policy on enterprises' green innovation, provides theoretical support and practical reference for sustainable development, and helps the government to formulate policies, enterprises to respond to policies, and guides enterprises to achieve better results in environmental aspects. The results of the study have a positive effect on advancing enterprise environmental protection, promoting green transformation, and realizing the harmonious coexistence of man and nature.

Keywords: Carbon emissions trading, Double-difference modeling, Green innovation capacity, High-quality development.

1. Introduction

With the acceleration of global industrialisation, our greenhouse gas emissions have been rising in recent years, putting unprecedented pressure on our ecological environment [1]. Global warming, as one of the most intuitive manifestations of this pressure, has triggered widespread concern in the international community. To meet this challenge, governments are endeavouring to introduce emission reduction policies to reduce greenhouse gas emissions and mitigate the effects of global warming. Among the many emission reduction strategies, carbon emissions trading has been widely used in practice due to its features such as flexibility and incentives [2][3].

Our country is now in a critical period of promoting high-quality development and modernisation that promotes the harmonious coexistence of human beings and nature. At the same time, our country has entered the critical stage of "double carbon", that is, the goal of "carbon peak and carbon neutral". In this context, green innovation has become an important force for economic growth and sustainable development [4]. Therefore, in-depth research and understanding of how carbon emissions trading affects the green innovation capacity of enterprises and its mechanism is of great theoretical and practical significance for giving full play to the important role of emission reduction policies in high-quality development and sustainable development [5].

Carbon emissions trading, as a market mechanism, effectively incentivises companies to strengthen their focus on green production and green technologies through a clear pricing mechanism. Under this mechanism, companies can buy and sell carbon emission rights to achieve their own

emission reduction objectives [6]. Such a flexible emission model not only reduces the company's emission costs, but also stimulates the company's enthusiasm for green innovation. In particular, the implementation of carbon trading has prompted the company to take proactive measures to reduce emissions, the main means of which include technological upgrading through the research and development of green technologies, so as to achieve the goal of emission reduction. Carbon trading improves green efficiency and enterprise performance at the same time. Carbon emission rights significantly enhance the level of green innovation of enterprises, and the baseline allocation is more capable of promoting green innovation of enterprises [7][8]. Through green innovation, enterprises can improve production efficiency and product quality, reduce energy consumption, reduce pollution to the environment, and achieve a win-win situation for both economy and environmental protection. We theoretically explore the impact of the carbon trading system on the green innovation and large-scale green innovation behaviours of non-state-owned enterprises (NSOEs), meanwhile, the carbon trading system can effectively enhance the green innovation and substantial green innovation of NSOEs in the case of insufficient competition. Compared with low-quality green technological innovation, carbon trading has a greater driving effect on high-quality green technological innovation. Meanwhile, green demand, industry competition and internal governance all contribute to the innovation incentive effect of carbon trading [9]-[11].

With the development of the "two mountains" theory, people have put forward higher requirements for ecological environment quality. The public environmental concern can

drive the green innovation behaviour of enterprises, and the dominant traits of enterprises can also affect the sensitivity of green innovation and public environmental concern [12][13]. It is further emphasised that media attention has a positive effect on the technological innovation of heavily polluting firms, and enhances the green technological innovation of firms by influencing governmental environmental regulation and increasing public participation.

The study provides a comprehensive and in-depth understanding of the relationship between carbon emissions trading and corporate green innovation, and provides strong empirical support for the government to formulate and adjust emission reduction policies. On this basis, a series of policy recommendations are put forward, aiming to promote enterprises to participate more actively in sustainable development, and to inject new impetus into the construction of ecological civilisation and high-quality development in China. Therefore, the possible marginal contributions of this paper are (1) analysing the heterogeneous impacts of carbon emissions trading policies from multiple dimensions such as region, nature of enterprises and technological capability, which provides a reference for understanding the differentiated effects of policies in different groups; (2) not only verifying the direct impacts of carbon emissions trading policies on enterprises' green innovations, but also, through the two intermediary variables of R&D inputs and the public's concern for the environment, it reveals the mechanism by which the policy affects the green innovation of enterprises.

2. Institutional Background and Research Hypotheses

2.1. Institutional Background

Carbon trading as a market mechanism aims to reduce greenhouse gas emissions globally on 9 May 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted by the United Nations Intergovernmental Panel on Climate Change (IPCC). Subsequently, the Kyoto Protocol (the Protocol), the first supplementary agreement to the Convention, was ratified in December 1997 in Kyoto, Japan. The Protocol utilises market mechanisms to reduce emissions of greenhouse gases such as carbon dioxide, treating it as a commodity, resulting in the trading of carbon emission rights.

In 2011, in accordance with the 12th Five-Year Plan's deployment of "building a carbon trading market in phases", the State launched carbon trading pilots in seven provinces across China. Since 2013, China's pilot carbon markets have been on-line for trading, which has effectively reduced emissions for enterprises in the pilot cities and regions. On 5 January, the 23rd executive meeting of the State Council adopted the Interim Regulations on the Administration of Carbon Emission Trading. The regulation is both a concrete measure to implement the spirit of the 20th Party Congress and an objective need for the development of China's carbon emissions trading market construction.

2.2. Research Assumptions

2.2.1. Carbon Emissions Trading Has a Positive Effect on Enterprise Green Innovation

In terms of economic incentives, the carbon emissions trading system implements an emissions permit system through the establishment of carbon emission quotas, and enterprises need to purchase additional emission rights in

order to exceed their allocated quotas. This economic incentive mechanism increases the costs of high-carbon emitting enterprises, prompting them to shift to cleaner and low-carbon production methods. Enterprises are incentivised to find more environmentally friendly production technologies and methods in order to avoid additional costs, thus driving the innovation and application of green technologies.

Market demand is also one of the main influences. As people pay more attention to environmental protection and sustainable development, consumers have more and more choices of environmentally friendly and low-carbon products and services. The implementation of the carbon emissions trading system has made it a competitive advantage for enterprises to reduce carbon emissions in the market. In order to meet the market demand, enterprises need to continuously innovate and introduce more environmentally friendly, energy-saving and low-carbon products and services to gain more market share and competitive advantages.

Hypothesis 1: Carbon emissions trading promotes enterprises' green innovation ability.

2.2.2. Carbon Emission Right Trading Promotes Enterprises to Increase R&D Investment

In order to reduce carbon emissions and obtain more emission credits, enterprises need to carry out technological innovation and R&D investment. This will involve the development of new production processes, and the growing consumer demand for green and low-carbon products and services, driven by the awareness of environmental protection and sustainable development. This has prompted them to increase their R&D investment in green technology and cleaner production, thus promoting the innovation and application of related technologies.

The implementation of the carbon emissions trading system has led to the elimination or transformation of certain traditional high-carbon emission industries. Under such circumstances, enterprises are forced to seek new directions of development and shift to more environmentally friendly and sustainable industrial sectors. This adjustment and transformation of industrial structure will inevitably prompt enterprises to carry out technological innovation and management innovation, thus promoting the development of green economy and the realisation of green innovation of enterprises.

Hypothesis 2: Carbon emissions trading enhances the R&D capability of enterprises and thus promotes enterprise green innovation.

2.2.3. Carbon Emissions Trading Enhances the Public's Concern for The Environment

The implementation of carbon emissions trading system makes carbon emissions no longer just a policy level discussion, but directly affects the production and consumption behaviour of enterprises. This direct economic impact makes the public pay more attention to the issue of carbon emissions and enhances their knowledge and awareness of environmental protection. The carbon emissions trading system will become one of the focuses of media attention. Various media channels will report news about carbon emissions trading, policy changes and information about carbon emissions of enterprises, thus enhancing the public's attention to the carbon emissions issue.

Hypothesis 3: Carbon emissions trading enhances the public's concern for the environment and thus promotes green innovation in enterprises.

3. Study Design

3.1. Empirical Model

In order to examine the impact of carbon emissions on the

$$Greeninability_{itd} = \alpha_0 + \alpha_1 \times did_{itd} + \alpha_2 \times Control_{it} + \delta_i + \delta_t + \delta_d + \varepsilon_{itd} \quad (1)$$

$$did_{itd} = period_t \times treat_{itd} \quad (2)$$

3.2. Variable Selection

3.2.1. Explained Variables

Enterprise green innovation level. The existing literature is not uniform in measuring the green innovation ability of enterprises, and most articles choose the number of green invention patent applications as a proxy variable. Considering that enterprises may have exaggerated the declaration of invention patents in order to establish a good green image and attract more investors. As a result, the number of patent applications can only reflect the importance of enterprises to green innovation, and cannot reflect the real green innovation ability of enterprises. This paper adopts enterprise green invention patent authorisation as the explanatory variable, which is expressed by Patent.

3.2.2. Explanatory Variables

The policy dummy variable (did) of the carbon emissions trading pilot. The constructed did is essentially the interaction term between the regional dummy variable and the time dummy variable (Treat*Post), if the region where the enterprise is located is a carbon emissions trading pilot, the regional dummy variable is taken as 1, otherwise it is 0; if the time is after the pilot year 2013, the time dummy variable is taken as 1, otherwise it is 0.

3.2.3. Control Variables

Considering that other factors may have a potential impact on corporate green innovation, this paper refers to select the corresponding control variables. They mainly include: enterprise size (Size), measured by the logarithm of the annual total assets of the enterprise; the number of years of establishment of the enterprise (Firm Age), which is obtained by the formula $\ln(\text{the current year year} - \text{the year of the company's establishment} + 1)$; the gearing ratio (Lev), measured by the ratio of the total liabilities at the end of the year to the total assets at the end of the year; and the return on equity (ROE), measured by the ratio of the net profit to the average balance of the total assets; Fixed assets ratio (Fixed), measured by the ratio of net fixed assets to total assets; Tobin's Q (Tobin Q), calculated by the formula $(\text{market capitalisation of outstanding shares} + \text{number of shares of non-outstanding shares} \times \text{net assets per share} + \text{book value of liabilities}) / \text{total assets}$; Growth, measured by the growth rate of operating income.

3.3. Data Source and Descriptive Statistics

This paper takes the listed enterprises in Shenzhen and Shanghai A-shares from 2007 to 2021 as the research samples, and collects the enterprises' green patent data and their financial data, of which the listed enterprises' green patent data comes from China Data Research Platform (CNRDS), and the financial data comes from the database of Cathay Pacific (CSMAR), and the data are processed as follows: (1) exclude the financial and insurance industry; (2) exclude ST, *ST and other samples; (3) excluding samples with serious missing data; (4) to avoid the effect of extreme values, this

pollution emission behaviour of enterprises, this paper constructs a double difference model, as shown in equation (1) and equation (2):

paper shrinks the variables up and down by 1%, and obtains a total of 27, 393 sample observations. Table 1 shows the results of descriptive statistics.

Table 1. Descriptive statistics

Variable	Observed value	Mean value	Standard error	Max value	Min value
Patent	27393	2.929	8.484	57	0
did	27393	0.130	0.336	1	0
Size	27393	22.13	1.326	26.08	19.21
Lev	27393	0.447	0.207	0.898	0.0510
ROE	27393	0.0680	0.131	0.405	-0.687
Fixed	27393	0.226	0.168	0.702	0.00200
Tobin Q	26745	2.137	2.785	259.1	0.641
Growth	27393	0.196	0.446	2.783	-0.592
Firm Age	27393	2.790	0.357	3.497	1.609

4. Empirical Analysis

4.1. Benchmark Regression

Based on the theoretical foundation and model construction of the previous paper, this paper takes the carbon emissions trading pilot as a quasi-natural experiment, and investigates the impact of policy effects on the real innovation behaviour of enterprises. Table 2 shows the results of the benchmark regression of the impact of carbon trading policy on the level of corporate green innovation, and overall the regression coefficients of the policy variables are significantly positive at the 1% level, indicating that there is a significant incentive effect of the carbon trading policy on the green innovation behaviour of enterprises in the pilot area, which verifies Hypothesis H1, and at the same time, indicates the applicability of Porter's effect in the Chinese market. The implementation of carbon trading policy is of great significance for enterprises to achieve green development and the government to achieve the goal of "double carbon".

Table 2. Reference regression

	Patent	
	(1)	(2)
did	0.8407*** (0.2079)	0.9444*** (0.2114)
cons	2.8237*** (0.0417)	-35.1209*** (2.8652)
control variable	No	Yes
fixed effect	Yes	Yes
brochure	26, 992	26, 341
R ²	0.679	0.688

4.2. Parallel Trend Test

The use of double difference as a measure relies on the parallel trend hypothesis, i.e., the experimental group and the control group need to meet the same trend before the occurrence of the policy, otherwise it is considered that the difference between the control group and the experimental group in the later period of the change is not due to the implementation of the policy, but may be due to its own

differences. In order to test the "parallel trend hypothesis", this paper takes the launch time of the carbon trading policy as the pilot year, conducts the parallel trend test based on the event study method proposed, and constructs the following

model:

$$GP_{it} = \alpha + \mu_1 D_{it}^{-5} + \dots + \mu_{10} D_{it}^4 + \gamma X_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (3)$$

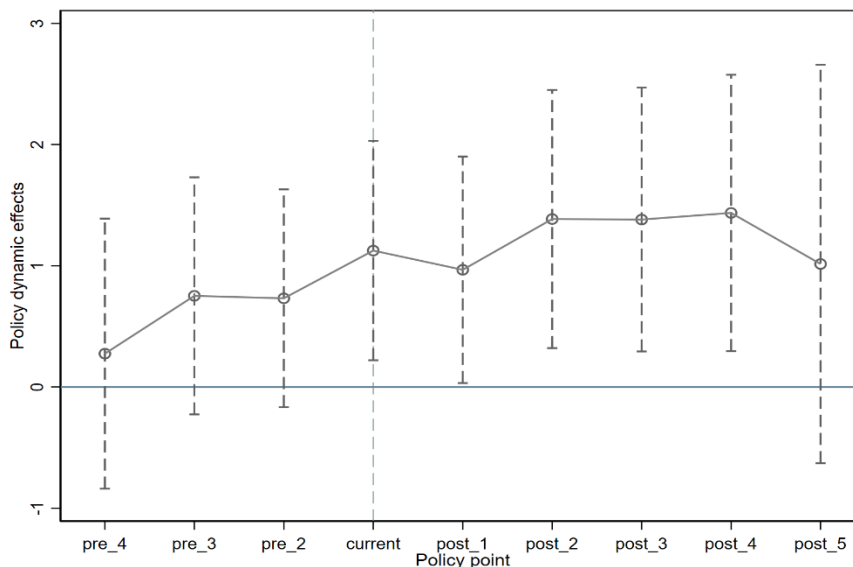


Figure 1. Parallel trend test

4.3. Robustness Tests

4.3.1. Placebo Test

In this paper, the treatment group is randomly selected from the sample, and the treatment objects of the disrupted policy pilot are regressed. Then the regression results of the above operation repeated 1000 times are plotted as a kernel density

plot. The results are shown in Figure 1, the distribution of the mean estimates of the regression results is significantly larger than the true estimates, and the coefficients around 0 of the regression results are not significant, so the result passes the placebo test, that is, the impact of carbon emissions trading on the green innovation behaviour of enterprises is not by chance.

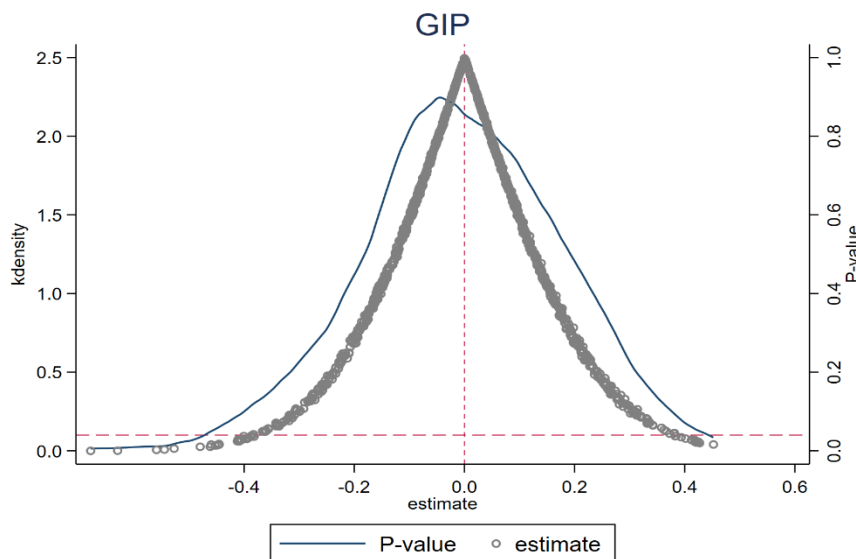


Figure 2. Placebo test

4.3.2. Excluding other policy effects and event shocks

This paper adds the policy dummy variables of the low-carbon city pilot for regression on the basis of the study, and the results are shown in column (1) of Table 3, which shows that the policy effect is still significant under the control of other policy variables. In addition, at the beginning of 2015, the "strictest environmental protection law in history" began to be implemented, followed by the environmental protection department announced five bylaws, such as the Measures for Implementing Continuous Daily Penalties, etc. Under the

constraints of the new environmental protection law, the enterprises' awareness of green development was gradually enhanced, and they consciously improved their green innovation capabilities. Finally, at the beginning of 2020, the outbreak of the new Crown Pneumonia epidemic had a great impact on the development of enterprises, which seriously affected the enterprises to carry out innovative activities. Based on this, this paper excludes the above years and re-runs the regression, and the results are shown in Columns (2) and (3), and the policy variables are still significantly positive.

4.3.3. PSM-DID

The double difference model requires the selection of policy pilot subjects to be random, and if there are significant individual differences between the treatment and control groups, it will lead to biased regression results. In order to exclude the interference of individual differences on the regression results and carry out sample selection correction, this paper uses propensity score matching to identify the

control group with similar characteristics in the treatment group for regression. In this paper, the above control variables are used as the characteristic variables and matched year by year using k-nearest neighbour matching with 1:1 and 1:3. The regression results are shown in columns (4) and (5) of Table 3, and the results remain significantly positive and consistent with the above results.

Table 3. Robustness test 1

	Excluding other policy effects and event shocks			PSM-DID	
	(1)	(2)	(3)	(4)	(5)
	Low-carbon city pilot policy shocks	Impact of the new environmental protection law	New Crown Pneumonia Outbreak Hits	1:1 nearest neighbour matching	1:3 nearest neighbour matching
D	0.6799*** (0.2369)	0.9338*** (0.2225)	0.8853*** (0.2074)	0.8736*** (0.2079)	0.8732*** (0.2079)
DC	0.4056*** (0.1541)				
cons	-35.2544*** (2.8647)	-35.4663*** (2.9667)	-35.6552*** (2.8556)	-36.7952*** (2.9845)	-36.8201*** (2.9915)
control variable	Yes	Yes	Yes	Yes	Yes
individual fixed effect	Yes	Yes	Yes	Yes	Yes
time fixed effect	Yes	Yes	Yes	Yes	Yes
brochure	26, 341	24, 021	25, 784	25, 613	25, 603
R ²	0.688	0.690	0.674	0.674	0.674

4.3.4. Controlling for fixed effects

This paper controls for city- and industry-level fixed effects based on the baseline regressions to further exclude uncertainty caused by the city-level and industry-level. Column (1) of Table 4 is the result of controlling for city fixed effects; column (2) is the result of controlling for industry fixed effects; and column (3) is the result of controlling for both industry and city fixed effects, and the regression coefficients are all positive at the 1% significance level.

4.3.5. Replacing Explained Variable Measures

In order to make the benchmark results of this paper robust, the number of green invention patent applications (Patentapply) is used to measure the level of green innovation of enterprises, replacing the number of green invention patent grants as an explanatory variable for the robustness test. The specific results are shown in column (4) and column (5) of Table 4. The policy dummy variable is significantly positive, consistent with the basic results of this paper.

Table 4. Robustness test 2

	Controlling for fixed effects			Replacement of explanatory variable measures	
	(1)	(2)	(3)	(4)	(5)
	cities	industry	Cities industry double fixing		
D	0.6503*** (0.1977)	0.8160*** (0.2107)	0.6150*** (0.1994)	2.4401*** (0.5538)	2.6272*** (0.5768)
cons	-37.8763*** (2.9952)	-36.3702*** (3.0052)	-37.0937*** (2.9970)	3.4204*** (0.1021)	-57.3432*** (6.1837)
control variable	Yes	Yes	Yes	No	Yes
fixed effect	Yes	Yes	Yes	Yes	Yes
cities fixed effect	Yes	No	Yes	No	No
industry fixed effect	No	Yes	Yes	No	No
brochure	26, 341	24, 021	25, 784	25, 613	25, 603
R ²	0.688	0.690	0.674	0.674	0.674

5. Further Analyses

5.1. Heterogeneity Analysis

5.1.1. Differences in the nature of enterprises

In this paper, according to the nature of enterprises, enterprises are divided into state-owned enterprises and non-state-owned enterprises for the heterogeneity test, and the test results are shown in columns (1) and (2) of Table 5. The results are shown in columns (1) and (2) of Table 5. Among them, the policy variables of state-owned enterprises are

significantly positive while those of non-state-owned enterprises are significantly negative. SOEs usually enjoy government support and more relaxed financing channels, which provide them with stable financial security and lower risk thresholds for green innovation. In addition, SOEs often assume a demonstration role in implementing national policies and environmental protection standards, so they are more likely to respond positively to policy requirements and invest in the research and development of clean technologies and green products under the carbon emissions trading mechanism. In contrast, non-state-owned enterprises face

more competitive market pressures and financing constraints, and may be more inclined to pursue short-term profits rather than long-term green transformation. In a carbon emissions trading system, these enterprises may view the cost of carbon emissions as a burden rather than an opportunity for green innovation, resulting in less positive investment and performance in green innovation than state-owned enterprises.

5.1.2. Differences in geographical location of enterprises

Due to the differences in regional economic development level, policy support and resource allocation, enterprises under different regions may have different reflections on environmental regulation policies. In this paper, according to the province where the enterprise is located, the 30 provinces and autonomous regions in China are divided into the eastern region and the central and western region for the test of heterogeneity, and the results of the test are shown in the columns of Table 5 (3), (4) and (5). The policy variables are significantly positive for firms in the eastern coastal cities, but not for firms in the central region, and even significantly negative for firms in the western region. This may be due to the fact that eastern coastal cities are usually economically developed and highly open, with better market systems and stronger technological innovation capabilities. In such an environment, it is easier for enterprises to obtain financial, technological and human resources support, so that they can respond positively to the carbon emissions trading policy and improve their competitiveness and economic efficiency through green innovation. In contrast, although the central region also has a certain industrial base and policy support in the process of development, it may be relatively insufficient in terms of capital, technology and talents, resulting in the incentive effect of carbon emissions trading on enterprises' green innovation being less obvious than that in the east. As

for the western region, due to the relatively low level of economic development and weak infrastructure and industrial base, enterprises may bear greater cost pressure in the face of carbon emissions trading, and lack of sufficient resources for green innovation, resulting in the final formation of "positive in the east, insignificant in the centre, and negative in the west" pattern of influence.

5.1.3. Differences in technological capabilities of enterprises

The carbon emissions trading mechanism aims to control and reduce greenhouse gas emissions through market instruments, while incentivising enterprises to adopt greener and more sustainable production methods. Under this mechanism, technology becomes a key factor for enterprises to respond to policy and market signals and carry out green innovation. In this paper, firms are classified into high-technology firms and low-technology firms according to the differences in their technological capabilities, and the test results are shown in columns (6) and (7) of Table 5. The policy variables of high-tech firms are significantly positive while those of low-tech firms are not significant. High-tech firms usually have stronger R&D capabilities and higher technological adaptability, which makes them more capable of utilising advanced environmental technologies to improve energy efficiency and the greenness of their production processes, thus playing an advantageous role in carbon emissions trading. On the contrary, low-tech enterprises may lack the capital, technology and human resources to carry out green innovation, making it difficult for them to effectively adjust their production processes and reduce emissions in the face of carbon emissions trading, resulting in these enterprises' response to carbon emissions trading being less positive and significant than that of high-tech enterprises.

Table 5. Heterogeneity test

	Nature of enterprise		geographic location			technical capability	
	state-owned business	non-state enterprise	eastern part	central section	western part	High-tech enterprises	Low-tech enterprises
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
D	1.7096*** (0.2916)	-0.8994*** (0.2495)	0.6612*** (0.2171)	-2.8011*** (0.6635)	-0.7247 (0.5085)	1.6571*** (0.2775)	-0.1616 (0.3426)
cons	-47.5556*** (5.5270)	-38.3434*** (3.5277)	-36.0750*** (3.7938)	-25.4779*** (5.0887)	-27.2912*** (7.2502)	-35.1465*** (3.2680)	-33.7005*** (5.4244)
control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
brochure	11, 502	14, 762	17, 859	4, 629	3, 841	15, 745	10, 509
R ²	0.735	0.644	0.713	0.594	0.644	0.719	0.687

5.2. Mechanism Test

Based on the theoretical analysis in the previous section, the mediation effect model is further constructed to test the

$$Patent_{itd} = \gamma_0 + \gamma_1 \times did_{itd} + \gamma_2 \times ct_{itd} + \gamma_3 \times tc_{itd} + \gamma_4 \times Control_{it} + \delta_i + \delta_t + \delta_d + \varepsilon_{itd} \quad (4)$$

Where: tc is the mediator variables for firms' R&D investment and regional public environmental concern, respectively, and ct_{itd} is the interaction term between the policy variables and the mediator variables.

5.2.1. R&D input effect

R&D investment is one of the key indicators of enterprise innovation capability, which not only directly affects the innovation output of enterprises, but also may change the

mechanism of intellectual property protection policy development affecting enterprises' green innovation performance.

degree of reliance on and the way of utilising intellectual property protection. In this paper, the total R&D investment is selected as the measure of enterprise R&D investment, and the results are shown in Table 6. The interaction term is significantly negative while the R&D input term is significantly positive. This indicates that there is a significant substitution relationship between R&D investment and the impact of carbon emissions trading policy on the innovation activities of enterprises, i.e., carbon emissions trading policy

and R&D investment each has a positive role in promoting green innovation, but the R&D investment of enterprises cuts down the promotion effect of carbon emissions trading policy on green innovation to a certain extent, which verifies Hypothesis 2.

5.2.2. Public monitoring effect

As public awareness of environmental protection increases, the market demand for green products and technologies rises accordingly, especially in those regions where environmental awareness is deeply rooted. This trend forces firms to increase their green innovation efforts under the protection of environmental regulatory policies in order to comply with stricter environmental standards and consumer preferences. In this paper, we refer to the study of other researchers, and search for "pollution" as a keyword in the Baidu search index to get the public environmental concern index by year and by region as a measure of the degree of public environmental concern in the region, and we get the results as shown in Table 6. The interaction term is significantly positive, which shows that the degree of regional public environmental concern plays a significant role in promoting the impact of carbon trading policy on corporate green innovation, indicating that the degree of regional public environmental concern plays a positive moderating effect on the innovation incentive effect of carbon trading policy, which verifies Hypothesis 3.

Table 6. Mechanism test

	Enterprise R&D investment	Level of public environmental concern in the region
did	0.5215*	-0.5400
	(0.2813)	(0.3991)
did*RD	-0.8133**	
	(0.3734)	
RD	2.2502***	
	(0.4386)	
did * Baidu		0.6279**
		(0.2890)
Baidu		0.0901
		(0.2487)
cons	-37.9086***	-38.9759***
	(4.1188)	(4.0904)
control variable	Yes	Yes
fixed effect	Yes	Yes
brochure	19, 096	19, 858
R ²	0.715	0.740

6. Conclusion and Implications

This paper adopts the data of non-financial A-share listed enterprises in Shanghai and Shenzhen from 2007 to 2021, and empirically analyses the impact of carbon emissions trading policy on corporate green innovation by using the DID model, and finds that: (1) the implementation of the carbon emissions trading policy can effectively promote the green innovation behaviours of enterprises; (2) from the point of view of heterogeneity, the carbon emissions trading policy has a more significant impact on the enterprises of the eastern region, state-owned enterprises, high-tech industry enterprises' green

innovation is more significant; (3) from the perspective of regulating role, in the process of carbon emissions pilot enterprise R&D investment on enterprise green innovation shows the policy substitution role, and the degree of public environmental concern has a positive regulating role on enterprise green innovation.

Based on the above findings, this paper puts forward the following suggestions: (1) Policy makers: Government departments can further improve the carbon emissions trading policy, and promote the green innovation behaviour of enterprises through more refined design and implementation. Differentiated policy measures can be taken to further enhance the effectiveness and relevance of the carbon trading policy for different regions, different ownership enterprises and different industries. (2) Enterprise managers: Enterprise managers should fully understand the role of carbon emissions trading policy in promoting green innovation, actively respond to the policy, and increase investment in green technological innovation. In particular, enterprises located in the eastern region, state-owned enterprises and high-tech industries should pay more attention to green innovation and include it as an important part of their development strategy. (3) Public Awareness: Government departments and relevant organisations can enhance public awareness of carbon emission issues and environmental protection by strengthening publicity and education, so as to further increase the public's concern for environmental issues. Increased public concern will further encourage enterprises to increase their investment in green innovation, forming a positive interaction between policy and public awareness. (4) Policy synergy: In the carbon emission pilot process, the government can combine the R&D investment of enterprises and the level of public concern for the environment to formulate more comprehensive policy measures. For example, by giving incentives or subsidies to enterprises for green innovation behaviours, they can be further incentivised to actively participate in the carbon emissions trading market, and promote enterprises to more actively respond to climate change and environmental issues.

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