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# Does the ETS Reduce the Carbon Pollution Intensity of the Region?

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## Abstract

**This article selects a sample of 276 cities from 2006 to 2021 and uses a difference-in-differences model to analyze the impact of carbon emission trading policies on enterprises' green transformation. The research results indicate that carbon emission trading policies can significantly reduce the carbon emission intensity of cities. Furthermore, after progressively adding control variables, the core explanatory variable remains significant, which fully demonstrates the robustness and reliability of the research conclusions. Based on the above research findings, this article proposes several suggestions regarding carbon emission trading policies, aiming to provide a reference for the optimization and improvement of related policies.**

## Keywords

**Carbon Emission Reduction Policy; Carbon Intensity; Level of Economic Development; Difference-in-Differences Model.**

## 1. Introduction

As global climate change becomes an increasingly pressing issue, how to effectively control carbon emissions and achieve a green, low-carbon transformation has become a key objective for policy makers worldwide. As a market-based mechanism for reducing emissions, carbon trading policies set emission quotas and allow for inter-regional transactions in emissions rights, motivating businesses to reduce their emissions at lower costs. Compared to traditional administrative measures, the carbon trading system is characterized by flexibility and economic efficiency, hence its widespread application in carbon reduction practices across countries and regions. In China, since the pilot launch of the carbon trading market, it has gradually expanded to cover the entire nation, serving as a crucial policy tool driving regional low-carbon development. However, due to significant disparities in economic development levels, industrial structures, and energy structures among various regions, the carbon trading policies generate varying degrees of emissions reductions in different areas. This particularly holds true with regards to the critical indicator of carbon intensity. Whether the carbon trading system can effectively promote the improvement of regional carbon efficiency remains to be thoroughly studied and empirically tested. Therefore, this paper aims to investigate the actual policy effects of carbon trading policies on regional carbon emissions intensity, in the hope of providing scientific grounds and policy suggestions for refining China's carbon market system.

## 2. Literature References

In recent years, carbon trading policies, as a market-based environmental regulatory tool, have garnered widespread attention and have gradually been applied in regional carbon emission

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reduction practices. Numerous empirical studies demonstrate that carbon trading policies have significant effectiveness in reducing the regional carbon intensity.

A subset of studies employed the difference-in-differences (DID) method in assessing China's carbon trading pilot projects, discovering that carbon trading policies effectively reduced carbon intensity in these pilot regions and to some extent promoted green technological innovation and economic efficiency improvements, thus generating the "Porter effect" [1]. Similarly, another study based on data from 30 provinces found that carbon trading policies not only effectively lowered carbon intensity in pilot areas but also had a positive spatial spillover effect on neighboring regions [2].

In addition, the mechanism through which carbon trading policies affect carbon intensity has also become a research focus. Studies have pointed out that carbon trading indirectly inhibits the growth of carbon emissions intensity by promoting structural optimization and technological progress [3]. At the city level, carbon trading policies have been proven to significantly improve urban environmental governance levels, and reduce city carbon intensity via green technological innovation, demonstrating a good dynamic cumulative effect [4]. However, some studies also indicate that there exist regional disparities and "green paradoxes" of government over-intervention in the implementation process of carbon intensity policies, suggesting that policy design should place greater emphasis on balancing market incentives and state intervention [5].

## 3. Research Data and Methodology

### 3.1. Data Sources and Variable Selection

We selected data from 276 cities spanning 2006 to 2021 as our research sample. In 2012, the State Development and Reform Commission's Office published a notice on the pilot work for carbon trading rights, followed by the launch of the first batch of carbon trading policy trials in Beijing, Tianjin, Shanghai, Shenzhen, Chongqing, Hubei, and Guangdong provinces in 2013. We chose city-level carbon emissions intensity as the explanatory variable, with the core explanatory variable consisting of the interaction term of policy virtual variables and time virtual variables. We selected provincial GDP levels (GDP), population density (Pop), industrial structure (Ind), technological level (Tec), and financial development degree (Fin) as control variables to accurately evaluate the effectiveness of policy implementation. The above data came from the National Bureau of Statistics and local statistical yearbooks.

### 3.2. Model Setting

$$Carbon_{it} = \beta_0 + \beta_1 \times did_{it} + \beta_2 \times Gdp_{it} + \beta_3 \times Tec_{it} + \beta_4 \times Fin_{it} + \beta_5 \times Pop_{it} + \beta_6 \times Ind_{it} \quad (1)$$

Among them, $i$ and $t$ represents the city and year, the dependent variable $Carbon_{it}$ represents the carbon emission intensity of the city $i$ in the $t$ year, and the core explanatory variable $did_{it}$ consists of the interaction terms of the policy dummy variable and the time dummy variable for the city $i$ in the $t$ year. If the city $i$ is a pilot province, the value is 1; otherwise, it is 0. If the carbon emission trading policy is implemented in the $t$ year, the value is 1; otherwise, it is 0. $Gdp_{it}$ , $Tec_{it}$ , $Fin_{it}$ , $Pop_{it}$ , $Ind_{it}$ represent the economic development level, technological development level, financial development level, population size, and industrial structure of t the city $i$ in the $t$ year.

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# 4. Empirical Analysis

## 4.1. Descriptive Statistics

**Table 1**. Descriptive Statistics

| Variable | N | Mean | p50 | SD | Min | Max |
|---|---|---|---|---|---|---|
| Carbon | 4,384 | 4.2021 | 2.9682 | 4.2333 | 0.1916 | 50.2158 |
| did | 4,384 | 0.0760 | 0.0000 | 0.2650 | 0.0000 | 1.0000 |
| Pop | 4,384 | 5.7452 | 5.9036 | 0.9255 | 0.6831 | 7.8816 |
| Gdp | 4,384 | 10.4934 | 10.5269 | 0.7238 | 4.5951 | 13.0557 |
| Ind | 4,384 | 0.4072 | 0.3989 | 0.1013 | 0.0001 | 0.8387 |
| Tec | 4,384 | 0.0154 | 0.0105 | 0.0160 | 0.0000 | 0.2068 |
| Fin | 4,384 | 2.3225 | 2.0015 | 1.1667 | 0.5879 | 21.3017 |

Table 1 presents the descriptive statistics of the main variables. From the data results, it can be seen that the standard deviation of the majority of the data is relatively small, indicating that the research data is relatively concentrated. This not only ensures the reliability of the data but also allows for an accurate assessment of the policy effects of carbon trading policies on carbon emission intensity at the prefecture level.

## 4.2. Parallel Trend Test

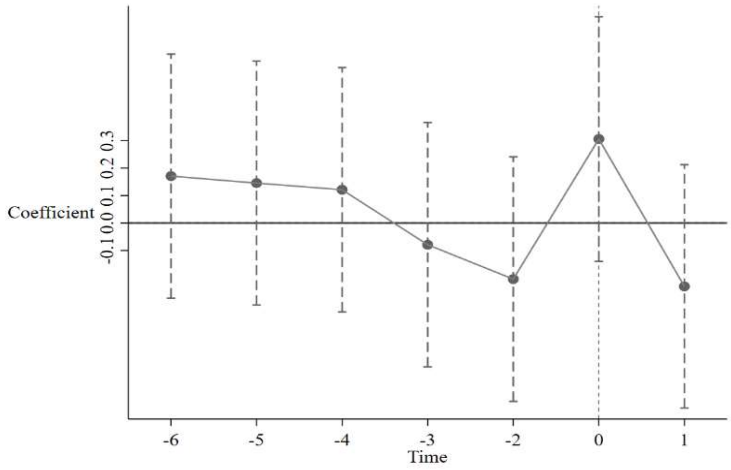



**Fig. 1** Parallel trend test

This article uses a double difference model, whose prerequisite is to meet the parallel trend test, that is, before the implementation of the carbon emission trading policy, the experimental group and the control group have a similar trend of change, which ensures the rationality of the control group as a counterfactual basis for the experimental group. We use 2007-2014 as the time window for the parallel trend test, incorporating the interaction terms of annual policy dummy variables and time dummy variables into the regression, adding control variables, and absorbing individual fixed effects and time fixed effects for regression analysis. We obtain the coefficients of the interaction terms for each year and produce Figure 1, which shows the results of the parallel trend test. From the figure, it can be seen that before the implementation of the carbon trading policy, the regression coefficients of the interaction terms fluctuate around 0 and are not statistically significant, indicating that the parallel trend test is passed. This suggests that before the implementation of the carbon trading policy, there is no significant difference in carbon emission intensity between the experimental group and the control group.

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## 4.3. Benchmark Regression Analysis

**Table 2.** Regression Results

| Carbon | OLS | FE | FE | FE |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| did | -1.1188*** | -0.2186* | -0.2250* | -0.2263* |
| | (0.2408) | (0.1252) | (0.1253) | (0.1263) |
| Gdp | | -2.8050*** | -2.8535*** | -2.8300*** |
| | | (0.1196) | (0.1289) | (0.1320) |
| Tec | | 14.4474*** | 14.2735*** | 14.0387*** |
| | | (2.4710) | (2.4770) | (2.4763) |
| Fin | | | -0.0449 | -0.0503 |
| | | | (0.0445) | (0.0447) |
| Pop | | | | 0.4719*** |
| | | | | (0.1566) |
| Ind | | | | 0.8875 |
| | | | | (0.5925) |
| _cons | 4.2871*** | 33.4296*** | 34.0463*** | 30.7434*** |
| | (0.0664) | (1.2527) | (1.3941) | (1.6921) |
| Fixation effect | N | Y | Y | Y |
| | | | | |
| N | 4384 | 4384 | 4384 | 4384 |
| adj. R2 | 0.0470 | 0.8920 | 0.8920 | 0.8923 |

This article uses a difference-in-differences model. Table 2 reports the regression results of the difference-in-differences model. Column (1) shows the OLS regression results, while Column (2) displays the regression results after including the level of urban economic development and technological advancement, controlling for city fixed effects and time fixed effects. The coefficient of the core explanatory variable is -0.2186, which is statistically significant at the 10% level, meaning that the carbon emissions trading policy significantly reduces carbon emission intensity in prefecture-level cities. Column (3) of Table 2 adds results based on the financial development level of the city, with the core explanatory variable remaining significant. Column (4) shows the results with the addition of urban population density and industrial structure, while absorbing individual fixed effects and time fixed effects. The policy effect coefficient is significant at the 10% level. According to the regression results in Column (4), it indicates that the carbon emission intensity in cities within the pilot areas decreases by 0.2263 units. The above research conclusions indicate that the carbon emissions trading policy significantly reduces carbon emission intensity in urban areas and that these conclusions are robust and reliable.

## 4.4. Placebo Test

The main purpose of the placebo test is to validate the robustness and reliability of research results, excluding the interference of other irrelevant factors, and ensuring that the causal relationship observed in the study is real, rather than due to random factors or model specification errors. Specifically, it ensures that the carbon emission intensity of prefecture-level cities is influenced by the carbon emission trading policy system rather than other unobservable factors. This paper conducts 1000 regressions by constructing a pseudo experimental group and a pseudo control group, and the generated distribution of coefficients is shown in Figure 2. In the figure, the red dashed line represents the density distribution of

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regression coefficients after random treatment, while the gray dashed line represents the true regression coefficient. We can observe that the distribution of regression coefficients from random treatment is mostly concentrated near the value of 0, and there is a significant difference from the true regression coefficient. The placebo test passes, indicating that the carbon emission intensity of prefecture-level cities is not influenced by other unobservable factors.

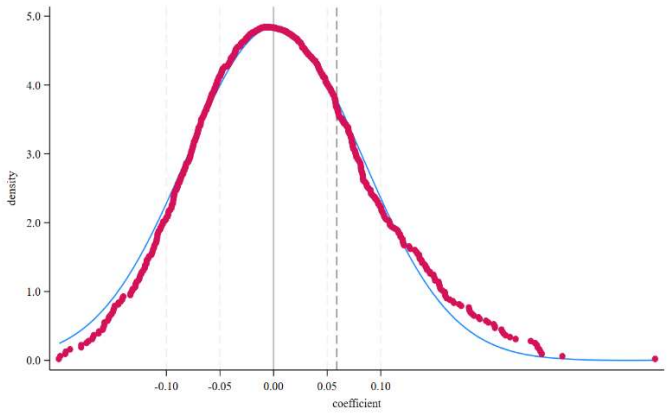



**Fig. 2** Placebo test

## 5. Conclusion and Recommendations

This paper uses a research sample of 276 cities from 2006 to 2021 and employs a difference-in-differences model to analyze the impact of carbon emissions trading policies on corporate green transformation. The research conclusions indicate that carbon emissions trading policies significantly reduce the carbon emission intensity of cities. Moreover, even after gradually adding control variables, the core explanatory variable remains significant, suggesting that our research conclusions are robust and reliable. Based on the above research findings, this paper presents some recommendations regarding carbon emissions trading policies.

First, improve the carbon pricing mechanism to attract more financial capital and promote the deep integration of carbon markets and financial markets. Second, expand the coverage of the carbon market to include more energy-intensive industries while lowering entry barriers. Third, strengthen capacity building, improve registration and trading rules, and enhance system stability and service convenience. Fourth, strengthen supervision and law enforcement, and establish a normalized compliance supervision mechanism. Fifth, conduct follow-up evaluations, regularly analyze prominent data quality issues, and optimize plans.

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