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Can Carbon Trading Pilot Policy Affect the Value of China's Manufacturing Firms? --Empirical Evidence from China's Manufacturing Sector from 2008 to 2019

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Abstract: *We study the impact of carbon trading pilot policy on the value of manufacturing firms in China. Based on the data of manufacturing listed companies in Shanghai and Shenzhen A-shares from 2008 to 2019, a double-difference empirical study was conducted to investigate the impact of the carbon trading pilot policy on the value of enterprises. It is found that the carbon trading pilot policy is significantly positively related to enterprise value, and this conclusion still holds significantly after a series of robustness tests such as the balanced trend test, the placebo test, and the PSM test. The analysis of the mechanism of action shows that green innovation has a mediating role in the process of enhancing enterprise value by the carbon trading pilot policy, and the green innovation activities of enterprises can strengthen the positive impact of this policy on enterprise value creation. Heterogeneity analysis reveals that when enterprises meet the conditions of non-state ownership, low pollution and low environmental regulation, the carbon trading pilot policy has a more significant effect on the value enhancement of manufacturing enterprises.*

Keywords: *Carbon Trading Pilot Policy, Enterprise Value, Green Innovation*

1. Introduction

In the face of the challenge of global warming, the issue of carbon emissions has become the focus of extensive international attention. Countries around the world have introduced various environmental policies to cope with the challenge, among which carbon trading policy is gradually becoming an important tool to cope with climate risks[1]. In 2005, the European Union (EU) region established the carbon emissions trading system (EUETS) for the first time, and then many countries actively followed suit and constructed their own carbon emissions trading markets respectively. As of 2024, the world has 25 carbon emissions trading systems. As the world's largest developing country and carbon emitter, China bears an important responsibility in carbon emission reduction. In order to promote the process of carbon emission reduction, China officially launched the carbon emission trading pilot project in 2011, and selected seven provinces and cities, including Beijing, Tianjin and Shanghai, to carry out the pilot project in 2013. In July 2021, the national carbon emissions trading market will be formally launched on-line. Therefore, we believe that in this context, it is of great practical significance to explore the impact of carbon trading pilot policies on corporate value.

At present, the exploration of the effectiveness of the carbon trading pilot policy is mainly carried out in two aspects. First, the impact of carbon trading policy on carbon emissions, some scholars believe that carbon trading pilot policy can significantly reduce carbon emissions in pilot areas. Carbon trading policy can reduce carbon emissions by promoting the enhancement of energy use rate. Some scholars have also suggested that the carbon trading market faces the problem of inaccurate quota allocation, which leads to the carbon trading market policy can not reduce carbon emissions in all regions. Secondly, the impact of carbon trading policy on the economic effects of enterprises, the research on the two is mostly focused on theoretical analysis, and the direction of research is mostly the macro level of the EU market. As some scholars have found, the implementation of carbon trading policies can enhance the corporate economy in pilot regions[2]; there are also views that the impact of carbon trading policies on the corporate economy is negative[3]; and some scholars believe that corporate value is not affected by the emergence of carbon trading policies[4]. It can be seen that

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existing studies still have big differences of opinion on the relationship between the two, so this paper tries to use the data of listed companies in the Chinese manufacturing industry to further analyze the impact of the carbon trading pilot policy on enterprise value using an empirical method.

The "Porter Hypothesis" suggests that properly designed environmental regulations can stimulate green innovation in regulated firms, which can offset some or even all of the costs of compliance with environmental regulations, thereby improving the competitiveness of firms, and that carbon trading policies, as a type of environmental regulation, have significantly contributed to the development of green innovation among Chinese firms. Green innovation is the driving force behind China's green development, pushing the Chinese economy toward environmentally friendly and sustainable operation, which coincides with the concept of the carbon trading pilot policy. Green innovation can not only reduce the harm to the natural environment by lowering the carbon emissions of enterprises, but also bring about the enhancement of economic value for the relevant enterprises. Therefore, when this paper discusses the relationship between carbon trading pilot policy and enterprise value, it is necessary to further analyze the role of green innovation in the process.

The possible marginal contributions of this paper are: first, it enriches the research related to the economic consequences of carbon trading pilot policies and the factors affecting firm value. Second, from the perspective of green innovation, it provides a new path for the research on the correlation between carbon trading pilot policies and enterprise value. Third, it increases the research scenarios for studying the relationship between carbon trading pilot policies and enterprise value. This paper further explores the heterogeneous impacts of carbon trading pilot policies on enterprise value from three aspects: the nature of enterprise property rights, the degree of pollution and the degree of environmental regulation.

2. Theoretical analysis and research hypothesis

2.1 Carbon Trading Pilot Policies and Corporate Value

Existing literature is still divided on whether the carbon trading pilot policy has a large impact on enterprise value. Some scholars believe that the carbon trading pilot policy has reduced corporate performance. This is mainly reflected in two aspects, one is that with the implementation of carbon trading policy, enterprises need to increase emission reduction inputs, which increases the cost of carbon emissions and thus reduces the value of the enterprise; the second is that high-carbon-intensity enterprises need to pay the cost of purchasing quotas when their carbon emissions exceed the initial quotas[5], and the price of carbon emissions will have a direct impact on the value of the enterprise. There are also views that the carbon trading pilot policy can significantly enhance enterprise value, which is mainly manifested in the following points: First, in the context of the implementation of the carbon trading pilot policy, the enterprise's carbon emissions are subject to strict supervision, so that the transparency and credibility of the enterprise's information has been enhanced; Second, the enterprises participating in the carbon trading pilot policy are able to send a positive signal to the community to respond to the call of the state, which in turn strengthens the reputation of the enterprise; Third, carbon quotas can be regarded as a valuable asset, and having a sufficient number of quotas is equivalent to acquiring assets that can be traded, thus increasing enterprise value[6].

We believe that the impact of the carbon trading pilot policy on enterprise value is mainly reflected in the following aspects: first, economic value. For enterprises with actual emissions lower than their quotas and good carbon emission management, they can sell the remaining quotas in the carbon market to obtain additional income[7]. For enterprises facing tight carbon quotas, if they achieve emission reduction through their own technological transformation and management optimization, they can avoid purchasing quotas at high prices in the market, thus saving costs. Second, market value. Under the carbon trading policy, enterprises that actively reduce emissions will establish a good social image, which is more likely to be recognized by consumers, partners and investors, and thus take advantage of the competition in the market[8]. Third, social value. The carbon trading pilot policy can provide innovation impetus for enterprises[9], in order to reduce carbon emission costs, enterprises will increase their efforts in low-carbon technology research and development, energy-saving and emission reduction equipment investment, and promote the progress and application of green technology. Based on this, this paper proposes hypothesis 1.

H1: The implementation of carbon emissions trading pilot policy can promote the enhancement of enterprise value.

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2.2 Carbon trading pilot policies, green innovation and corporate value

Green innovation is an important means to improve the effectiveness of emission reduction and pollution control[10]. First, the carbon emissions trading market has a resource allocation function. Through carbon emissions trading, more funds can be introduced into low-carbon enterprises, alleviating the financing constraints faced by enterprises in the process of green innovation, and increasing their willingness to engage in green innovation[6]; second, the price mechanism of carbon emissions trading will enhance the motivation of enterprises to engage in green innovation. High-carbon firms are likely to face the quota shortage problem. Therefore, in order to minimize the impact of carbon trading on the firm's operational performance, firms will improve their corporate governance performance by carrying out green innovations[11]. Finally, the carbon trading policy can strengthen the external environmental regulation pressure on enterprises in order to improve their green development initiative. Environmental regulation will lead to an increase in the cost of pollution control and force enterprises to increase R&D investment[12]. In addition, enterprises' green process innovation can form high-value as well as hard-to-be-substituted key resources, forming a competitive advantage[13]. Based on this, this paper proposes hypothesis 2.

H2: Carbon trading pilot policy can promote enterprise value enhancement through green innovation activities, and green innovation shows a certain mediating role between the two.

3. Sample selection and study design

3.1 Sample Selection and Data Sources

In this paper, the data of Chinese Shanghai and Shenzhen A-share listed companies in the manufacturing industry from 2008 to 2019 are selected as samples, in which the data related to green innovation patents are from CNRDS database, the data on the degree of environmental regulation are from annual reports of listed companies and China provincial databases, and all other financial data are from CSMAR database. In order to improve the accuracy of the data, this paper processed the relevant data as follows: (1) excluding samples of ST-class companies; (2) excluding abnormal samples with asset-liability ratios greater than 1; (3) excluding samples with missing variables, and finally obtained 14,736 observations. In order to avoid the influence of extreme values, this paper has carried out the shrinking of the upper and lower 1% (Winsorize) treatment for all continuous type variables.

3.2 Variable Definition

The dependent variable of this paper is firm value. This paper uses the return on net worth (Roe), a measure of firm performance, to measure firm value.

The independent variables in this paper are the pilot carbon emissions trading policy dummy variables (Did).On October 29, 2011, China's Development and Reform Commission (DRC) issued the Notice on Carbon Emissions Trading Pilot Work, which launched the pilot carbon emissions trading work in seven provinces and municipalities, namely Shenzhen, Shanghai, Beijing, Guangdong, Tianjin, Hubei and Chongqing. Therefore, the treatment group in this paper is the manufacturing enterprises belonging to the regions of Shanghai, Beijing, Guangdong, Tianjin, Hubei and Chongqing, and the manufacturing enterprises in other provinces are the control group. Starting from June 18, 2013, the above provinces and cities start carbon emissions trading respectively. Therefore, this paper takes 2013 as the year of policy implementation, before 2013 is set as the non-pilot period, and after 2013 (including 2013) is set as the pilot period. The dummy variable of carbon emissions trading pilot policy (Did) is measured by the value of treat*post. If the enterprise is in a pilot province or city, Treat=1, and vice versa is 0. The enterprise whose treat takes the value of 1, the year in which the policy is implemented in the province or city and the following years post=1, and vice versa is 0. The enterprise whose treat takes the value of 0, post is always 0. In the case where treat*post takes the value of 1 is the experimental group, i.e., the enterprise is a pilot enterprise of the pilot policy for carbon emission rights trading, and verse it is the control group.

We selected the gearing ratio (Lev), the size of the firm (Size), the age of the firm (Age), the growth capacity of the firm (Growth), the proportion of independent directors (Indep), the proportion of the first largest shareholder's shareholding (Top1), and the size of the board of directors (Board) as the control variables, and the related variables are defined as shown in Table 1.

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Table 1: Definition of variables.

Variable Type	Variable Name	Variable Symbol	Variable Definition
Dependent Variable	Firm Value	*Roe*	Net Profit / Average Net Assets
Independent Variables	Dummy Variable of Carbon Emission Trading Policy	*Did*	The interaction term between whether the enterprise is located in a carbon emission trading pilot province/city and the policy implementation year.
	Dummy Variable of Policy Implementation Scope	*Treat*	If an enterprise is located in a province where the carbon emission trading pilot policy is implemented, Treated = 1; otherwise, Treated = 0.
	Dummy Variable of Policy Implementation Time	*Post*	If the year is 2013 or later when the carbon emission trading pilot policy was implemented, Post = 1; otherwise, Post = 0.
Control Variables	Asset-liability Ratio	*Lev*	Total Liabilities at Year-end / Total Assets at Year-end
	Firm Size	*Size*	Ln (Total assets at the end of the year for the enterprise)
	Firm Age	*Age*	Ln (The current year - the year the enterprise was established + 1)
	Firm Growth Capability	*Growth*	(Current Year Operating Income / Previous Year Operating Income) - 1
	Proportion of Independent Directors	*Indep*	Number of independent directors / Number of board members
	Proportion of shares held by the largest shareholder	*Top*1	Number of shares held by the largest shareholder / total number of shares
	Board Size	*Board*	Ln (Number of Board Members)
	Year Dummy Variable	*Year*	It is 1 if it belongs to the year, otherwise 0.
	Industry Dummy Variable	*Industry*	It is 1 if it belongs to the industry, otherwise 0.

3.3 Model Building

In order to test the impact of the carbon emissions trading pilot policy on firm value, we constructed a benchmark regression model (1) to test it:

$$Roe_{i,t} = \alpha_0 + \alpha_1 Did_{i,t} + \sum Controls_{i,t} + \eta_t + \theta_k + \varepsilon_{i,t} \tag{1}$$

In this context, the subscripts i, t, and k represent the company, year, and industry, respectively. The dependent variable $Roe_{i,t}$ denotes the corporate value of company i in year t. The independent variable $Did_{i,t}$ represents the dummy variable for the carbon emission trading policy. The control variables (Controls) are presented in Table 1, and $\varepsilon_{i,t}$ represents the random disturbance term. Additionally, we also control for year fixed effects ($\eta_{i,t}$) and industry fixed effects ($\theta_{i,t}$) in the model.

4. Benchmark Regression and Mechanism Test

4.1 Descriptive Statistics

Table 2 reports the results of descriptive statistics for the main variables. The results show that the difference between the 25th and 75th percentile of firm value (Roe) is large, indicating that there are still large differences in the enterprise value of the Chinese manufacturing industry. Moreover, the standard deviation of the indicators of enterprise size and age of enterprises reaches 21.92 and 16.02 respectively, indicating that the Chinese manufacturing enterprises are significantly different in terms of their growth stages and development cycles. The descriptive statistics of other control variables are similar to previous authoritative literature, so we will not repeat them.

Table 2: Descriptive statistics.

Variables	Obs	Mean	SD	P25	Median	P75
Roe	14736	0.0729	0.1196	0.0319	0.0762	0.1283
Lev	14736	0.3867	0.1987	0.2252	0.3741	0.5301
Size	14736	21.9191	1.1582	21.0800	21.7533	22.5660
Age	14736	16.0223	5.4897	12.0000	16.0000	20.0000
Growth	14736	0.2867	6.6403	-0.0040	0.1186	0.2687
Indep	14736	37.3538	5.2950	33.3300	33.3300	42.8600
*Top*1	14736	0.3460	0.1416	0.2349	0.3299	0.4380
Board	14736	2.1299	0.1898	1.9459	2.1972	2.1972

4.2 Main Regression Analysis Based on DID

Table 3 reports the results of the benchmark regression on the impact of carbon trading pilot policies on firm value. It can be seen that before and after adding the control variables, the coefficients of the core explanatory variable Did are 0.0074 and 0.0055 respectively, both of which are significantly positive at the 5% level, indicating that the carbon trading pilot policy can significantly promote the enhancement of the value of the manufacturing enterprises, and Hypothesis H1 can be verified. And from the perspective of economic significance, after the implementation of the carbon trading pilot policy, the average enterprise value increased by 7.5% (0.0055/0.0729), which indicates that the carbon trading pilot policy plays a significant role in promoting the enhancement of enterprise value.

Table 3: Impact of carbon emissions trading policies on firm value.

Variables	(1) *Roe*	(2) *Roe*
Did	0.0074***	0.0055**
	(3.04)	(2.39)
Controls	No Control	Control
Year	Control	Control
Industry	Control	Control
_cons	0.0571***	-0.4275***
	(6.65)	(-14.58)
N	14736	14736
$Adj.R^2$	0.045	0.160

Note: *, **, and *** denote 10%, 5%, and 1% significance levels, respectively; t-values in parentheses are calculated using robust standard errors. The following table is the same unless otherwise stated.

4.3 Robustness Test

4.3.1 Parallel Trend Dynamic Effect Test

The parallel trend test is a prerequisite for this paper to use Did model for empirical analysis. Therefore, this paper refers to the research method of Beck and Levkov (2010)[14], selects the three years before and after the enterprises are included in the carbon trading pilot policy as the research interval, and adopts the construction of dummy variables for each time period to estimate the regression coefficients, and then draws the relevant graphs for comparison. Pre_i represents the dummy variable of the i-th year before the enterprises were included in the scope of the pilot policy; current represents the year when the enterprises were included in the pilot policy and were the experimental group; post_i represents the dummy variable of the i-th year after the enterprises were included in the pilot policy. According to the test, before the implementation of the carbon trading pilot policy, the estimated coefficients of the enterprise value and the dummy variables are not significantly different from 0 in the three time periods before the occurrence of the policy, and the confidence intervals all contain 0, which indicates that the two groups have the same trend of change, in line with the parallel trend hypothesis. As can be seen from Figure 1, before the implementation of the carbon trading pilot policy, the estimated coefficients of the enterprise value and the dummy variables are not significantly different from 0 in the three time periods before the occurrence of the policy, and the confidence intervals all contain 0, which indicates that the two groups have the same trend of change, in line with the parallel trend hypothesis. After the occurrence of the policy, none of the confidence intervals of the estimated coefficients contains 0, and the fluctuation amplitude of the enterprise value is significantly enlarged from 2013 onwards, and there is a significant increase, which further indicates that the carbon trading pilot policy has a positive impact on the increase of the value of Chinese manufacturing enterprises.

4.3.2 Placebo Test

The impact of carbon trading policies on firm value may be confounded by some unobservable factors. For this reason, this paper adopts a placebo test by randomly assigning pilot provinces. This is done by constructing a new experimental group through 500 random samples to ensure that the core explanatory variable Did does not affect the explained variable Roe, and at the same time obtaining the coefficients of Did and the corresponding P-value in each sample. According to the test results, in these 500 random samples, the coefficient of Did is mostly distributed near 0 and the P-value is greater than 0.1, this result fully indicates that this placebo test is valid.

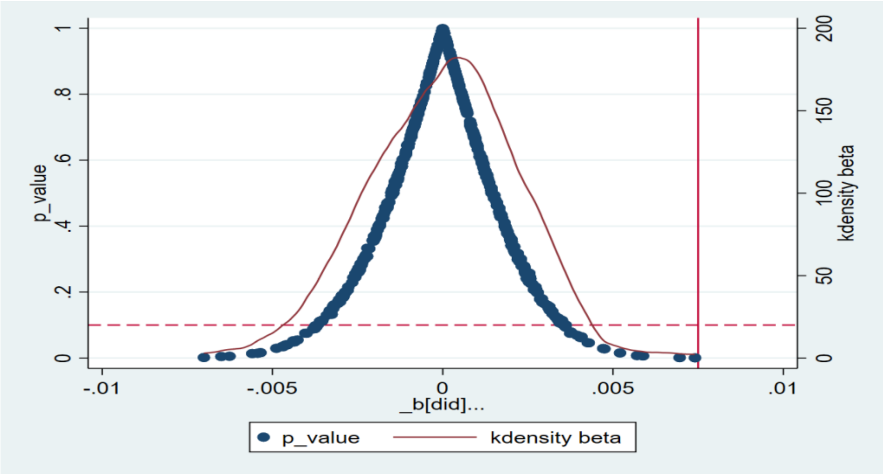

Figure 1: Placebo test.

Note: The X-axis represents the estimated coefficients from 500 randomly assigned Did. The curves are the estimated kernel density distributions and the dots are the associated p-values. The vertical line is the estimate from column (2) of Table 3 in the benchmark regression.

4.3.3 Propensity Score Matching (PSM)

Since the pilot provinces of carbon emission rights are determined by the government after examining them according to their various indicators, provinces above a certain level of carbon emissions will be included in the list, so this may generate endogeneity problems due to sample selectivity bias. Therefore, in order to further ensure the reliability of the findings, this paper applies the PSM method to carry out the robustness test of the model. By balancing the distribution of characteristics between the treatment group and the control group, the PSM method can effectively reduce the endogeneity problem caused by sample selection bias. In this paper, the 1:1 nearest-neighbor matching method is used to carry out sample matching using gearing ratio, firm size, firm age, firm growth, proportion of independent directors, proportion of shareholding of the first largest shareholder, and size of the board of directors as covariates. After completing the matching process, the estimation operation is implemented again based on the observations obtained from the matching.

According to the results of the balance test before and after the matching of the relevant variables in this paper are shown in Table 4, if the absolute value of the standard deviation of the sample variables after the matching is not more than 20%, that is, it is in line with the standard of matching of the variables. As can be seen from Table 4, the absolute value of the standard deviation of each variable after the sample has been matched is less than 10%, while the probability P corresponding to the t-value is significantly higher than 10%. This indicates that the matching estimation results are valid, and can provide a reliable basis for subsequent analysis. Column (1) of Table 5 reports the regression results of the PSM-DID test, which shows that the coefficient of Did remains significantly positive at the 5% level after matching, indicating that the findings of this paper remain robust.

Table 4: Comparison of sample means before and after matching.

Variables	Type	Mean		%bias	%reduct	t-test		V(T)/V(C)
		Treated	*Control*		|bias|	t	P>|t|	
Lev	Unmatched	0.37725	0.39003	-6.5		-3.43	0.001	0.89*
	Matched	0.37725	0.37864	-0.7	89.1	-0.32	0.751	0.95
Size	Unmatched	22.014	21.885	11.0		5.95	0.000	1.12*
	Matched	22.014	22.053	-3.3	69.7	-1.42	0.155	1.00
Age	Unmatched	17.391	15.537	33.6		18.22	0.000	1.14*
	Matched	17.391	17.429	-0.7	97.9	-0.31	0.756	1.24*
Growth	Unmatched	0.32159	0.27437	0.7		0.38	0.704	1.14*
	Matched	0.32159	0.20001	1.8	-157.5	1.07	0.285	36.00*
Indep	Unmatched	38.041	37.11	17.3		9.41	0.000	1.20*
	Matched	38.041	37.946	1.8	89.8	0.75	0.455	1.03
Top1	Unmatched	0.34185	0.34753	-4.0		-2.14	0.032	1.14*
	Matched	0.34185	0.33889	2.1	47.9	0.90	0.366	1.13*
Board	Unmatched	2.0991	2.1408	-21.6		-11.78	0.000	1.21*
	Matched	2.0991	2.1056	-3.4	84.3	-1.45	0.148	1.08*

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Table 5: Regression results of robustness test.

Variables	(1)	(2)	(3)	(4)
	PSM-DID	Two-way Fixed Effects	Replacing the Dependent Variable	
	Roe	*Roe*	*Roa*	*TobinQ*
Did	0.0070**	0.0072*	0.0020*	0.1366***
	(2.13)	(1.74)	(1.78)	(5.72)
Controls	Control	Control	Control	Control
Year	Control	Control	Control	Control
Industry	Control	No Control	Control	Control
Firm	No Control	Control	No Control	No Control
_cons	-0.4481***	-0.7823***	-0.1685***	8.9197***
	(-9.79)	(-6.62)	(-12.75)	(32.04)
N	6028	14592	14736	14736
Adj.R^2	0.158	0.361	0.271	0.308

4.3.4 Two-way Fixed Effects Model

To mitigate the endogeneity problem caused by omitted variables that do not change over time, this paper replaces the "year + industry" fixed effects in the benchmark regression model with "year + individual" two-way fixed effects to re-test the benchmark regression model. Column (2) of Table 5 reports the regression results of the two-way fixed effects model test. The results show that after adding control variables, the coefficient of Roe is significantly positive at the 10% level, indicating that the carbon emission trading policy can significantly enhance corporate value.

4.3.5 Replacing the Dependent Variable

In order to eliminate the possibility of the explanatory variables measures affecting the regression results, this paper chooses Return on Total Assets (Roa) and Tobin's Q (TobinQ) as the alternative indicators of firm value. Columns (3) and (4) of Table 5 present the results after replacing the explanatory variables, and the results show that the regression coefficients of Did are both significantly positive at the 10% level, indicating that the findings are still robust.

4.4 Mechanism Test Based on Green Innovation

According to the aforementioned theoretical analysis, We use the number of green invention patents and the number of green utility patents to measure the overall effect of green innovation, and based on the mediation effect model, we test the mediation role played by green innovation in the process of carbon trading pilot policy to promote enterprise value enhancement.

Table 6 reports the relevant results of the mechanism test. As can be seen in column (2), the coefficient of Did is significantly positive at the 1% level. Column (3) further adds the mediating variables based on column (1), and the results show that the coefficient of Did is still significantly positive at the 1% level, and the coefficient of Green is also significantly positive at the 1% level, which indicates that green innovation plays a part of the mediating role in the process of the carbon trading pilot policy to promote the value enhancement of the enterprises.

Table 6: Results of the mechanism test.

Variables	(1)	(2)	(3)
	Roe	*Green*	*Roe*
Did	0.0055**	0.0803***	0.0049**
	(2.39)	(4.57)	(2.15)
Green			0.0070***
			(5.92)
Controls	Control	Control	Control
Year	Control	Control	Control
Industry	Control	Control	Control
_cons	-0.4275***	-6.2619***	-0.3837***
	(-14.58)	(-27.18)	(-12.78)
N	14736	14776	14736
Adj.R^2	0.160	0.213	0.162

5. Heterogeneity Analysis

The carbon trading pilot policy incentivizes firms to reduce emissions by setting a cap on carbon emissions and allowing them to trade emission allowances. The impact of this policy on firm value may be affected by a combination of factors such as firms' own and industry characteristics, so we need to further study the impact of different factors on the mechanism of the two. Therefore, we attempt to analyze the heterogeneous impacts of the carbon trading pilot policy on corporate value from the perspectives of ownership nature, pollution degree, and environmental regulation intensity.

5.1 Ownership Nature

State-owned enterprises (SOEs) and non-SOEs have different behavioral patterns in carbon emissions trading. SOEs usually have close relations with the government and strong financial strength, and are more likely to obtain government subsidies or preferential loans, which may reduce their cost pressure in carbon trading, thus making the impact of the carbon trading pilot policy on their performance limited. At the same time, SOEs tend to comply with the policy rather than pursuing profit maximization, so they may ignore the negative impact on corporate profits when facing the carbon trading policy. Therefore, this paper argues that compared with SOEs, the carbon trading pilot policy will further promote the value enhancement of non-SOEs.

Based on this, we distinguish the research sample into two groups of SOEs and non-SOEs according to the nature of property rights, and conduct regression analysis separately. As can be seen from columns (1) and (2) of Table 7, carbon emission rights do not have a significant effect on enterprise value in the sample of state-owned enterprises, however, the effect of the carbon trading pilot policy on enterprise value in the sample of non-state-owned enterprises is significantly positive at the 5% level, which suggests that the value enhancement of non-state-owned enterprises is more pronounced under the influence of the carbon trading pilot policy.

5.2 Pollution Intensity

Due to the differences in pollutant emissions of different types of enterprises, their reliance on carbon emissions trading is also significantly different. Heavy polluters have large carbon emissions, resulting in actual emissions close to or even higher than the initial quota, so these enterprises need to purchase quotas through the carbon trading market, which will certainly incur a certain amount of carbon emission costs, thus lowering the profits of enterprises. Therefore, this paper expects that the carbon trading policy promotes corporate value more significantly in the group of non-heavy polluters.

Manufacturing enterprises with Chinese industry codes "C17, C19, C22, C25, C26, C28, C29, C30, C31, C32" are identified as high-pollution enterprises, and others are classified as non-high-pollution enterprises. The regression results are shown in Columns (3) and (4) of Table 7. It can be seen that in the non-high-pollution enterprise group, the impact of carbon emission trading on corporate value is significantly positive at the 1% level, while there is no significant relationship in the high-pollution enterprise group. This indicates that the carbon trading policy has a significantly stronger impact on the value of non-high-pollution enterprises than on high-pollution enterprises.

5.3 Intensity of Environmental Regulation

Different degrees of environmental regulation have obvious differences in the way enterprises realize their own value through carbon trading. When the degree of environmental regulation is high, subject to the influence of strict environmental protection regulations, the relevant enterprises may have invested more money to reduce emissions in the early stage, and the marginal cost is relatively high, in this case, we believe that the impact of carbon trading policy on enterprise value may not be significant. When the degree of environmental regulation is low, due to less environmental protection policies in the previous period, carbon trading becomes an incentive for low-carbon emitting enterprises, and also constitutes a greater pressure on high-carbon emitting enterprises, so there is a greater potential for enterprises to reduce emissions. Therefore, we expect that the carbon trading policy will have a better effect on promoting the value of enterprises with a low degree of environmental regulation.

In order to test this hypothesis, we use the proportion of the amount invested in pollution control of waste gas and water in the year of the location of listed companies to the industrial output value of that year to measure the degree of environmental regulation. We categorize the degree of environmental regulation into two groups of high and low environmental regulation according to the annual industry median of environmental regulation intensity and perform group regression. As shown in columns (5) and (6) of Table 7, carbon trading policy is significantly and positively related to firm value at the 5% level in the sample with low environmental regulation, while there is no significant relationship in the sample with high environmental regulation, which suggests that carbon trading policy enhances the value of firms with low environmental regulation more significantly.

Table 7: Heterogeneity analysis.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	SOEs	Non-SOEs	High-Pollution	Non-High-Pollution	High Environmental Regulation	Low Environmental Regulation
Did	-0.0010	0.0063**	0.0016	0.0068***	-0.0004	0.0081**
	(-0.21)	(2.44)	(0.34)	(2.58)	(-0.11)	(2.43)
Coefficient Difference Test	0.081		0.090		0.029	
Controls	Control	Control	Control	Control	Control	Control
Year	Control	Control	Control	Control	Control	Control
Industry	Control	Control	Control	Control	Control	Control
_cons	-0.5339***	-0.3175***	-0.4418***	-0.4205***	-0.4501***	-0.4103***
	(-10.98)	(-4.40)	(-6.53)	(-12.62)	(-10.34)	(-11.22)
N	4637	10099	3985	10751	7467	7269
$Adj.R^2$	0.208	0.163	0.184	0.161	0.180	0.151

6. Conclusions and Implications

We empirically examined the impact of carbon trading pilot policy on manufacturing enterprise value using the double-difference method, and tested the robustness of the benchmark regression based on the balanced trend test, placebo test, and PSM test. This paper finds that there is a significant positive correlation between the carbon trading pilot policy and the value of manufacturing enterprises, which indicates that the carbon trading policy has a facilitating effect on the enhancement of enterprise value in this industry. The analysis of the mechanism of action concludes that green innovation has a mediating role in the process of enhancing enterprise value by the carbon trading pilot policy, and the green innovation activities of enterprises can strengthen the positive impact of the policy on enterprise value creation. Heterogeneity analysis reveals that when enterprises meet the conditions of non-state ownership, low pollution and low environmental regulation, the carbon trading pilot policy has a more significant effect on the value enhancement of manufacturing enterprises.

Based on the research in this paper, we put forward recommendations in the following three aspects. First, the government should improve the quota allocation and market mechanism. For one thing, the government should adopt the "baseline method and dynamic adjustment" mechanism for key industries, set differentiated carbon emission baselines, upgrade the energy efficiency benchmark standards to national standards, and increase the proportion of free quotas for enterprises with advanced production capacity. For another, the carbon emission market should gradually shift from free quota allocation to quota auctions to optimize the efficiency of resource allocation. Second, for non-state-owned enterprises, a certain degree of flexibility can be given in the allocation of carbon quotas and trading rules to encourage their active participation in the carbon market. For enterprises with high pollution degree, the government should set stricter emission reduction targets and a gradually tightening quota system to force them to carry out green transformation. For enterprises with high environmental regulation intensity, the government should avoid conflicts or overlaps between policies, organically combine relevant policies, and jointly promote the improvement of enterprise performance. Third, the government should establish special green innovation funds to provide some fund assistance and low-interest loans for enterprises to carry out green innovation projects, give tax relief preferences to enterprises for R&D investment and equipment purchase used for green innovation, so as to reduce the cost of green innovation and improve the enthusiasm of enterprises for innovation.

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