The Impact of Carbon Emissions Trading Scheme on Corporate Financial Performance: Based on the Moderating Effect of Carbon Prices

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Abstract—**Based on data from A-share listed companies in the Shanghai and Shenzhen markets from 2009 to 2020, this study used the PSM-DID (Propensity Score Matching-Difference in Differences) method to empirically examine the impact of carbon emissions trading scheme (ETS) on corporate financial performance and its effect mechanisms. The empirical results indicate that the implementation of ETS effectively enhances corporate financial performance among pilot companies. Additionally, the results indicate that carbon prices have a moderating effect between ETS and corporate financial performance, whereby higher carbon prices strengthen the impact of ETS on corporate financial performance. The influence mechanisms find that ETS improves corporate financial performance primarily driven by promoting corporate green innovation capacity and enhancing corporate social responsibility. Notably, only the sample group with higher carbon prices exhibits this effect. Overall, the implementation of the ETS contributes to improving the ecological environment and enhancing business operations, thus playing a pivotal role in reconciling environmental benefits with economic interests.**

Index Terms—**Carbon emissions trading scheme, Difference in Differences, corporate financial performance, carbon price.**

I. Introduction

THE carbon emissions trading scheme (ETS) is a financial policy tool, a market-based incentive for environmental conservation, and an indispensable constraint motivation mechanism to ensure the timely fulfillment of the "double carbon goal". China initiated the ETS pilot with the issuance of the “Notice on Carrying out the Carbon Emissions Rights Trading Pilot Work” in 2011, leading to the official launch of the nationwide unified carbon trading market in 2021, which means that nationwide carbon trading kicked off. Over ten years, the carbon trading market pilot has achieved significant achievements. By March 2021, more than 20 industries and nearly 3,000 key emitting enterprises participated in the carbon trading market, with a cumulative transaction value of around RMB 10.47 billion. Pilot enterprises have successfully achieved both control over emissions of carbon in total and intensity. Nevertheless, the operational challenges of enterprises have intensified in recent years due to external factors. The implementation of ETS has enabled companies to gain economic benefits by selling surplus carbon allowances. However, the pursuit of carbon emission targets will inevitably raise the cost of emission reduction [1]. Thus, it is imperative to address this issue to effectively realize the "double carbon goal" and facilitate the green transformation of the economy, ultimately contributing to the sustainable development of businesses.

In pursuit of low-cost industrialization and profit maximization, companies' pollution emissions have caused negative externalities for society and the environment. To address these negative externalities, measures must be taken to internalize the externalities. The carbon market, derived from the theories of environmental property rights and ecological modernization, is regarded as a viable approach for tackling the "negative externalities" associated with carbon emissions [2], [3]. With the gradual implementation of ETS in China, there is much concern about how the effectiveness of the policy. Although the main objective of ETS is to facilitate sustainable green development among enterprises [4], the process of transitioning and upgrading to green technologies may increase the costs of emission reduction [5]. Consequently, relevant studies have presented three distinct perspectives on this matter: Firstly, the positive view of ETS. Proponents argue that ETS provides policy incentives that stimulate green technological innovations [6], [7], ultimately achieving carbon emission reductions and enhancing the economic and social benefits of enterprises [8]-[10]. Additionally, companies can generate revenue by selling excess carbon allowances, thereby partially offsetting the expenses associated with pollution control measures and improving their overall financial position [11]. Secondly, the negative views of ETS. drawing from neo-classical economics, maintain a negative outlook. Opponents argue, based on neo-classical economics, that ETS increases pollution control costs, leading to lower productivity [12]. Xie *et al.* (2014) found that investments in environmental research and development yield negligible returns in terms of business performance [13]. Similarly, Chen *et al.* (2021) discovered that ETS significantly inhibits green innovation, thereby diminishing corporate cash flow and anticipated revenues [14]. Lastly, the uncertainty view

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of ETS. According to some, ETS exhibits a U-shaped relationship with financial performance [15]. Ge *et al.* (2021) identified an inverted "N" threshold effect, whereby ETS initially inhibits financial performance, then promotes it, before eventually hindering it again [16].

In summary, the existing literature on the microscopic effects of ETS lacks conclusive evidence. Additionally, there are relatively few studies that investigate the mechanisms of ETS on corporate financial performance and fail to elucidate the role of carbon prices in such influence. Consequently, this study conducts theoretical and empirical analysis using a sample of A-share listed companies in the Shanghai and Shenzhen markets in China between 2009 and 2020. This paper may contribute the following marginal contributions: (1) With the launch of the nationwide carbon trading market, the application of ETS is expanding and its impact on corporate behavior is more prominent, for which reason, this paper contributes to the empirical foundation of policy effects by investigating the impact of ETS on corporate financial performance. (2) Through the theoretical analysis and empirical examination to identify the mechanism by which ETS affects the financial performance of firms, this paper finds out the role of the policy mechanism, providing insights for maximizing policy effectiveness and exploring sustainable green development paths for corporations. (3) This paper enhances policy mechanisms and optimizes carbon market trading by analyzing and testing the moderating effect of carbon prices.

In this scholarly article, the further research framework is structured in the following manner. Section 2 of this paper analyzes the theoretical foundations and the list of research hypotheses. The research design adopted can be illustrated in Section 3. We lay out the empirical results and discussion in Section 4. This paper ends with the conclusions and recommendations in Section 5.

II. Theoretical analysis and research hypothesis

A. ETS and corporate financial performance

According to Coase's theory of property rights, the cause of environmental problems stems from the lack of clearly defined property rights over environmental resources [17]. Carbon emissions rights, specifically, refer to the legal rights granted to companies to emit greenhouse gases into the atmosphere, which represents a limited right to utilize environmental resources [18]. On the one hand, ETS implementation incentivizes companies to pay more attention to energy conservation and emission reduction [19], and actively conduct research and development focused on emission reduction technologies, leading to cost-saving outcomes [20]. Additionally, the issuance of carbon allowances limits enterprises' carbon emissions. To fulfill the carbon quota target, companies may initially reduce production levels to achieve short-term carbon emission reductions. However, this approach does not encourage long-term sustainable development. Consequently, driven by the ETS, enterprises are proactively engaged in emission reduction activities, such as increasing research on emission reduction technology or investing in emission reduction equipment, etc. These efforts optimize resource utilization, enhance production efficiency [21]-[23], and result in long-term savings of scarce elements (i.e., carbon emissions rights) [24]. By doing so, companies circumvent additional costs associated with purchasing carbon allowances or facing environmental penalties, ultimately achieving cost-saving effects via compliance [25]. On the other hand, the implementation of ETS can bring extra economic benefits to corporations [26]. Quota, as a property right, can be considered valuable assets possessing both real and option values [27]. Companies can obtain cash inflows by selling any excess carbon emissions allowances they possess [28]. Moreover, participating in carbon market trading signals a corporation's active commitment to social responsibility, thereby enhancing its credibility and reputation [29]. A company with a favorable reputation can maintain its customer loyalty [30], enhancing its influence and brand competitiveness by establishing a positive corporate image [31]. As a result, sales revenue and corporate value are effectively augmented. As a result of the above theoretical analysis, the hypothesis is proposed:

H1: The implementation of ETS has a favorable impact on the financial performance of companies.

B. Moderating effect of the carbon price

The carbon price is determined by the interaction of supply and demand in the carbon market, with revenue incentives and cost constraints effect. On the revenue incentive side, carbon price reflects the scarcity of carbon allowances, and higher prices signify greater market demand. By selling surplus allowances at a higher carbon price, companies can earn more revenue, which motivates their carbon reduction investment and enhances their intention of green technology research and development [32]-[35]. Not only to ensure compliance but also to improve corporate financial performance. In terms of cost constraints, under the carbon quota constraint, companies can choose low-carbon investments to achieve emission reduction and compliance [36]. However, companies incur investment fees for the research and development of low-carbon technologies or purchase fees for acquiring such technologies. Alternatively, companies can choose to purchase carbon emissions rights to meet compliance requirements, which incurs a purchase fee. Consequently, the implementation of ETS has a cost-constraint mechanism for companies. In situations of relatively low carbon prices, companies with higher carbon reduction costs may prefer to purchase carbon allowances from the market instead. Conversely, higher carbon prices necessitate larger costs for purchasing carbon allowances, compelling companies to favor low-carbon technology production, thereby achieving a reduction in carbon emission intensity [37]. Furthermore, investing in low-carbon technologies has long-term benefits for companies in terms of carbon reduction, whereas purchasing carbon allowances only offers short-term compliance relief or cost reduction. On the one hand, the higher carbon price stimulates companies to reduce emissions through increased revenue, on the other hand, the cost constraint mechanism of the carbon market motivates firms to enhance investment in low-carbon technologies [38]. This, conversely, enhances their capacity to reduce

emissions and improves their financial performance [39]. Considering the aforementioned theoretical analysis, the following hypothesis can be put forward:

H2: The implementation of ETS has a greater impact on corporate financial performance under high carbon prices.

III. Research Design

A. Data source

The initial sample of this study consists of A-share listed companies in Shanghai and Shenzhen markets from 2009 to 2020. To ensure the reliability of the empirical findings, the sample underwent a screening process according to the criteria below: (1) Exclusion of firms under special treatment (ST). (2) Exclusion of firms in the missing data. (3) Exclusion of companies in the real estate and finance insurance sectors. (4) We selected the first batch of firms included in the pilot list in Beijing, Tianjin, Shanghai, Guangdong, Hubei, Chongqing, and Fujian to form the treatment group, with other listed firms assigned as the control group. This resulted in 1162 samples for the treatment group and 7282 samples for the control group, with 6369 sample observations obtained after PSM matching. As the ETS was in the promulgation stage in 2011, its impact on overall carbon emissions was relatively limited, and the pilot provinces began publishing the list of pilot companies successively in 2013. Therefore, the year 2013 was considered as the policy implementation time point for this study. The corporate financial data were derived from the CSMAR database, the list of firms included in carbon trading was acquired from the List of Carbon Emission Trading Enterprises published by the carbon trading markets of seven provinces, and the carbon price data were sourced from each carbon emission trading market. All continuous variables were scaled down between the first and last 1% levels to mitigate the effect of extreme samples.

B. Description of variables

Dependent variable

Return on assets (*Roa*). This paper used return on assets as a proxy of corporate financial performance, which is computed as the ratio of current net income to average total assets. Additionally, *Tobin Q* is utilized as a robustness test proxy.

Independent variable

Difference-in-differences (*DID*) is the core explanatory variable, denoted as *DID=treat*time*. *treat i*s considered as a dummy variable of the policy pilot companies, indicating whether the firm participates in ETS (1 if included, 0 otherwise). *time* is considered as a dummy variable of policy pilot time, representing the point in time before and after policy implementation (1 for 2013 and later, 0 for pre-2013). To mitigate multicollinearity, the model excludes "*treat*" and "*time*".

Mediating variables

Green innovation (*GI*). This variable is operationalized as the number of green patent applications from public companies.

Corporate social responsibility (*CSR*) is founded on the 12 items contained in the social responsibility disclosed in the CSMAR database. Each item disclosure is assigned one point, the maximum social responsibility score of each company's year is 12 and the minimum is 0. Finally, the social responsibility score is standardized.

Moderating variable

Carbon price (*Price*). This paper is grouped by using annual industry averages of carbon prices, above-average carbon prices are labeled as 1 (High carbon price group), and below-average prices are labeled as 0 (Low carbon price group).

Control variable

Control variables are selected from the dimensions of corporate financial operation and corporate governance status. The financial operation dimension includes firm size (*Size*), firm age (*Age*), firm growth (*Growth*), and leverage (*Lev*). The governance dimension includes shareholder proportion (*CP*) and independent director ratio (*Indira*). Table 1 provides detailed information regarding the main variable selection and definitions.

TABLE I: Variable selection and definition

Variable	Symbol	Measurement
Dependent variable	*Roa*	Current net income to average total assets ratio
Independent variable	*DID*	time*treat
Mediating variables	*GI*	The number of green patent applications
	CSR	Social responsibility index
Moderating variable	*Price*	The annual industry average of carbon prices
Control variable	*Size*	Natural logarithm of total assets
	Age	Natural logarithm of the company's public age
	Growth	Operating income growth rate
	Lev	Total liabilities divided by total assets
	CP	The shareholding ratio of controlling shareholders
	Indira	Number of independent directors divided by the size of directors

C. Model Construction

We treated ETS as a quasi-natural experiment, with the treatment group consisting of firms of ETS pilot provinces and the remaining firms forming the control group. To examine what impact ETS has brought to corporate financial performance, we constructed the double difference model as follows:

$$Roa_{it} = \beta_0 + \beta_1 DID_{it} + \lambda X_{it} + \gamma_t + \eta_j + \delta_r + \varepsilon_{it}. \quad (1)$$

where the subscripts *i*, and *t* represent the firm and year. The dependent variable, Roa_{it} stands for the financial performance of *i* firm at year *t*. The core explanatory variable, DID_{it} is a double difference estimator. β_0 is the constant term of the model, β_1 is the key factor of concern, which reflects the direction and degree of influence of ETS on corporate financial performance. If β_1 is positive, the policy implementation effect is the same as expected. X_{it}

represents control variables. To exclude the effects of different years, provinces, and industries, the text adds corresponding fixed effects, γ_t represents the time fixed effect, δ_r represents the industry fixed effect, η_j represents the province fixed effect, ε_{it} as a random error term.

The stepwise regression method is employed to examine the influence mechanism of ETS on corporate financial performance, i.e., the following model constructed based on (1).

$$M_{it} = \alpha_0 + \alpha_1 DID_{it} + \lambda X_{it} + \gamma_t + \eta_j + \delta_r + \varepsilon_{it}, \quad (2)$$

$$Roa_{it} = \theta_0 + \theta_1 DID_{it} + \theta_2 M_{it} + \lambda X_{it} + \gamma_t + \eta_j + \delta_r + \varepsilon_{it}. \quad (3)$$

where, M denotes the mediating variables, consisting of green innovation and social responsibility. The remaining variables are to be defined as in (1).

IV. Empirical Results and Discussion

A. Descriptive statistics

We conducted descriptive statistics of the sample. As indicated in Table 2, *Roa* serves as an indicator of the disparity in profitability among different firms. The mean value of *Roa* is 0.042, and the median value of 0.041. Additionally, the maximum and minimum values are 0.236 and -0.301, respectively. These results indicate substantial variation in corporate financial performance within the sample, with the existence of remarkably outstanding financial performance samples. Furthermore, most control variables exhibit means that surpass their corresponding standard deviations, reflective of enhanced stability among these variables. Table 2 displayed the descriptive statistics for this sample.

TABLE II. Descriptive statistics of the variables

Variable	N	Mean	P50	SD	Min	Max
Roa	8444	0.042	0.041	0.072	-0.301	0.236
Size	8444	22.14	21.88	1.486	19.38	26.75
Age	8444	2.880	2.944	0.341	1.946	3.555
Growth	8444	0.151	0.097	0.368	-0.596	2.141
Lev	8444	0.426	0.420	0.208	0.052	0.916
CP	8444	0.361	0.350	0.164	0	0.760
Indira	8444	0.381	0.364	0.057	0.333	0.600
GI	8444	2.969	0	10.12	0	77
CSR	8444	1.682	1.946	0.574	0	2.303
Price	8444	33.27	28.14	20.15	6.411	86.43

B. PSM balance test

To solve the sample self-selection issue, we opted for six covariates (*Size, Age, Growth, Lev, CP, Indira*) for PSM matching. We assigned firms in the pilot provinces of ETS to form the treatment group, and the remaining firms formed the control group. Analysis of the variables before and after matching, as shown in Table 3, reveals significant differences in all variables before matching, except for the *Age* variable which did not exhibit significant differences. However, after matching, the absolute deviation rates of all variables decreased to less than 10%, indicating a significant reduction compared to the pre-matching values. Furthermore, none of the t-tests conducted after matching yielded significant differences. These findings suggest that the sample selection bias was successfully mitigated through sample matching, thereby using the double-difference model enables a more reliable assessment of ETS affects the financial performance of companies.

TABLE III. PSM balance test

Variable	Unmatched / Matched	Mean		Bias (%)	Bias reduction ratio (%)	t-test	
		Treated	Control			t	P>|t|
Size	U	22.738	21.992	53.7	98.9	23.25	0.000
	M	22.738	22.746	-0.6		-0.17	0.863
Age	U	2.755	2.766	-2.8	16.5	-1.17	0.243
	M	2.755	2.765	-2.3		-0.69	0.492
Growth	U	0.149	0.179	-7.1	99.9	-2.60	0.009
	M	0.149	0.150	-0.0		-0.00	0.999
Lev	U	0.465	0.425	19.6	85.1	7.76	0.000
	M	0.465	0.472	-2.9		-0.87	0.383
CP	U	0.400	0.362	23.6	91.7	9.91	0.000
	M	0.400	0.397	2.0		0.57	0.567
Indira	U	0.378	0.375	7.4	88.0	3.23	0.001
	M	0.378	0.379	-0.9		-0.26	0.798

C. Parallel trend test

This paper employed the parallel trend test for ensuring the validity of the double-difference model. We constructed dummy variables for the period before and after the implementation of ETS, with the year 2013 serving as the time point (*current*). The years before 2013 were set as pre_i (i=2，3) and the years after 2013 were set as pos_j (j=1，2，3). Among these, the year before 2013 (*pre_1*) was taken as the base year and not included in the parallel trend test. The results presented in Figure 1 revealed that the regression coefficients for the pre-ETS period (*pre_3* to *pre_2*) were negative and insignificant, suggesting no significant difference between the treatment and control groups before the policy implementation. In contrast, the regression coefficients for the post-ETS period (*post_1* to *post_3*) were positive and significant, initially demonstrating that the ETS has a significant positive impact on firms' financial performance and the policy implementation shows a continuum effect.

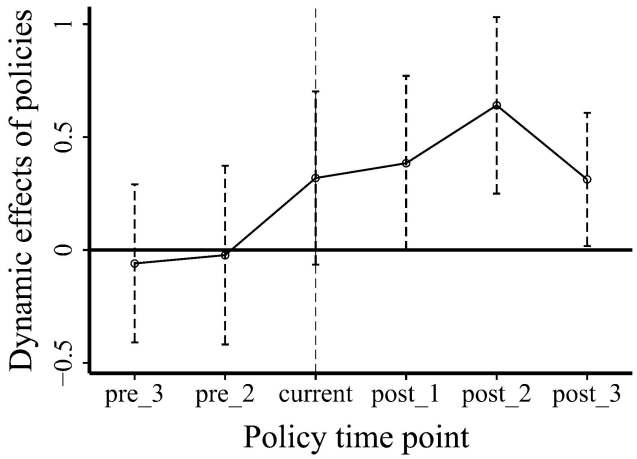

Fig. 1. Parallel trend check chart

D. Benchmark regression

Table 4 presents the regression results of the impact of ETS on corporate financial performance. The full sample is examined by Column (1) and Column (2). Column (1) displays that the coefficient for *DID* is significantly positive

at the 1% level with 0.007, showing that ETS implementation has a positive impact on corporate financial performance, and H1 is supported. In Column (2), the regression explores what effect policy implementation has on lagged-period financial performance. The coefficient of the DID_{t-1} is found to be significant at the 1% level with 0.009. These findings demonstrate that the positive influence of ETS on corporate financial performance remains not only in the current period but also in the lagged period, which further supported H1.

Turning to the grouped samples based on carbon prices, Column (3) and Column (4) list the regression results. The insignificant coefficient of *DID*, in Column (3), indicates that the implementation of ETS has no significant effect on corporate financial performance in the low carbon price group. However, in Column (4), a significant coefficient for *DID* is observed at the 5% level with 0.006 in the high carbon price group. This suggests that specifically in the high carbon price group, ETS has a positive effect on firms' financial performance, and its impact is not significant in the low carbon price group. These results highlight the role of carbon prices as a moderator between ETS and corporate financial performance, aligning with H2.

TABLE IV. Benchmark regression

VARIABLES	(1)	(2)	(3)	(4)
	Full sample		Low carbon price	High carbon price
DID	0.007*** (3.64)		0.004 (1.61)	0.006** (2.44)
DID_{t-1}		0.009*** (3.08)		
Size	0.008*** (14.56)	0.007*** (8.23)	0.007*** (9.01)	0.008*** (10.97)
Age	0.002 (1.01)	0.012*** (3.72)	0.006** (2.16)	-0.001 (-0.20)
Growth	0.052*** (26.34)	0.054*** (16.38)	0.060*** (19.66)	0.055*** (19.45)
Lev	-0.144*** (-41.65)	-0.143*** (-25.45)	-0.139*** (-28.39)	-0.139*** (-30.32)
CP	0.052*** (13.33)	0.055*** (8.76)	0.051*** (9.46)	0.052*** (9.90)
Indira	-0.040*** (-3.40)	-0.020 (-1.11)	-0.037** (-2.24)	-0.040*** (-2.64)
Constant	-0.090*** (-6.65)	-0.118*** (-5.38)	-0.081*** (-4.22)	-0.083*** (-4.70)
Year fixed effects	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
N	6,369	2375	3074	3295
Adj-R^2	0.348	0.342	0.355	0.352

Note： *** p<0.01, ** p<0.05, * p<0.1; the value in parentheses is the t-statistic (same as below).

E. Robustness test

Method 1 Replacement of the dependent variables

The robustness test was conducted employing *Tobin Q* as a proxy for assessing corporate financial performance. *Tobin Q*, which reflects investors' future return expectations and the competition and development strength of corporations to some extent, serves as a convincing measure of corporate financial performance. Column (1) in Table 5 displays a significant coefficient of *DID* at the 1% level with 0.236, implying that the ETS contributes a substantial and positive influence on corporate financial performance in the pilot areas. Thus, the conclusions drawn in this study are reasonably robust.

Method 2 Excluding the impact of other policy effects

Furthermore, alongside the influence of the ETS, other policy events may also affect corporate financial performance, potentially introducing bias into the above-mentioned results, such as the implementation of the 13th Five-Year Plan for Energy Conservation and Emission Reduction in 2016. To mitigate the influence of other policies, the influence of the 13th Five-Year Plan was controlled for, and a new regression was conducted. Specifically, the year 2016 and beyond were taken to be 1, and 0 for before 2016. From column (2) of Table 5, there is a meaningful positive correlation between *post* and *Roa*, signifying that the implementation of the 13th Five-Year Plan significantly affects corporate financial performance. Moreover, even after excluding the influence of the 13th Five-Year Plan, the coefficient of *DID* remains remarkable at the 10% level with 0.006, implying that the ETS continues to exert a significant impact on corporate financial performance after excluding concurrent policy effects.

Method 3 Temporal placebo test

For the placebo test, this study assumed the implementation of ETS to have occurred in 2012. Column (3) of Table 5 demonstrates that there is a positive but not significant coefficient of *DID*, indicating that the effectiveness of ETS on corporate financial performance is not coincidental. This further confirms the robustness of the previous findings.

TABLE V. Robustness test

VARIABLES	(1)	(2)	(3)
	Tobin Q	Excluding the impact of other policy	Temporal placebo test
DID	0.236*** (2.89)	0.006* (1.91)	0.0001 (0.06)
post		0.006** (2.07)	
Constant	1.389 (1.30)	0.099*** (2.78)	0.067*** (4.61)
Controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
N	5,120	6369	6369
Adj-R^2	0.427	0.570	0.160

Method 4 Policy placebo test

To ascertain whether the improvement in financial performance among pilot corporations primarily originates from the adoption of ETS rather than from other unobservable factors, 500 iterations of random sampling were performed for *DID* using the Permute command.

Figure 2 shows the distribution of regression coefficients centered around zero and normally distributed. The regression coefficients are located on the left side of the true regression coefficient of 0.007. Consequently, it can be concluded that the observed enhancement in financial performance among the pilot corporations predominantly stems from the implementation of ETS, rather than being driven by other unobservable factors.

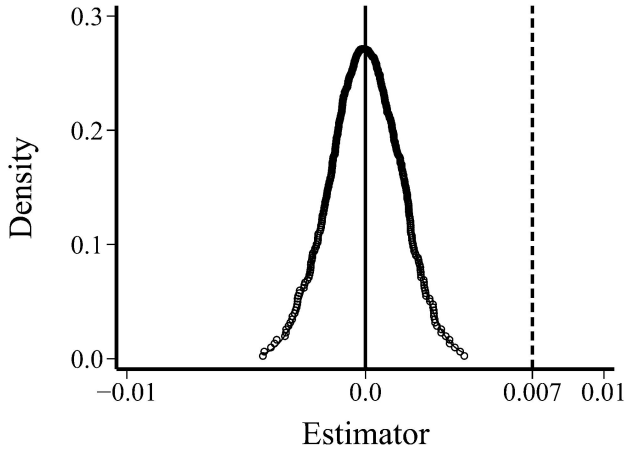

Fig. 2. Policy placebo test

F. Mechanism Test

Due to the theoretical analysis presented above, this study posits that the adoption of ETS can effectively facilitate corporate green innovation, leading to long-term emission reduction and subsequently enhancing corporate financial performance. Consequently, an effective pathway of ETS - green innovation - corporate financial performance may exist. Furthermore, the implementation of ETS can also foster the synergistic development of economic and social effects by enhancing corporate social responsibility. Hence, there may be an effective pathway of ETS - corporate social responsibility - corporate financial performance exists. Therefore, this section aims to separately investigate the mediating effects of green innovation and social responsibility in EST and corporate financial performance.

Test 1 The mediating effect of green innovation

According to the full sample regression results reported in Table 6, we observed that when *GI* is defined as the dependent variable, the value of *DID* coefficient is significant at the 5% level with 1.015, implying that the ETS positively promotes corporate green innovation. The coefficients of *GI* and *DID* on *Roa* are significant at the 1% level with 0.006 and 0.0002 respectively. This suggests that ETS can improve corporate financial performance by promoting green technology innovation outputs, signifying that green innovation acts as a partial mediator between ETS and corporate financial performance.

The results obtained from the analysis of samples grouped by carbon price in Table 6 show that the coefficient of *DID* is positive but not significant when *GI* is viewed as the dependent variable in the low carbon price sample group, showing that green innovation plays no moderating role in the low carbon price group. Conversely, the regression coefficient for *DID* is significantly positive in the high carbon price sample group, demonstrating that the implementation of ETS dramatically boosts green innovation in businesses only in the high carbon price group sample. When the dependent variable is *Roa*, the coefficient of *DID* remains remarkably positive in the high carbon price group, indicating that green innovation acts as a partial intermediary in the high carbon price group. These findings suggest that the influence of ETS on improving corporate financial performance through green innovation is more pronounced in the presence of higher carbon prices.

TABLE VI. Intermediary test results of green innovation

VARIABLES	Full sample		Low carbon price		High carbon price	
	GI	*Roa*	*GI*	*Roa*	*GI*	*Roa*
DID	1.015**	0.006***	0.503	0.004	1.440***	0.006**
	(2.30)	(3.60)	(1.23)	(1.56)	(3.07)	(2.37)
GI		0.0002***		0.0002*		0.0003***
		(4.07)		(1.89)		(3.65)
Constant	-57.632***	-0.092***	-41.19***	-0.084***	-37.56***	-0.080***
	(-17.62)	(-6.66)	(-13.35)	(-4.31)	(-12.06)	(-4.40)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	6291	6291	3038	3038	3253	3253
Adj-R^2	0.136	0.347	0.160	0.361	0.129	0.359

Test 2 The mediating effect of corporate social responsibility

Based on the regression results presented in Table 7 for the full sample, we observed that when *CSR* acted as the dependent variable, the regression coefficient of *DID* is significantly at the 1% level with 0.099, showing that the implementation of ETS significantly enhances corporate social responsibility. Similarly, the regression coefficients of *DID* and *CSR* on *Roa* are remarkably different with values of 0.005 and 0.003, respectively. These findings indicate that ETS has the potential to improve corporate financial performance by enhancing corporate social responsibility, suggesting that corporate social responsibility has a partial intermediary effect between ETS and corporate financial performance.

The regression results are based on carbon price grouped samples as presented in Table 7. In the low carbon price sample group, the influence of *DID* on *CSR* is significantly positive, however, the difference between the influence of *DID* on *Roa* is not significant. This indicates that corporate social responsibility does not serve as an intermediary in the low carbon price group. Conversely, among the high carbon price sample group, when *CSR* is considered as the dependent variable, the coefficient of *DID* is significant at a 1% level with 0.104, and both the coefficients of *DID* and *CSR* on *Roa* are significant with 0.005 and 0.003, respectively. These findings reveal that corporate social responsibility plays a partially intermediating function in the relationship between ETS and corporate financial performance in the high carbon price group. Overall, it can be concluded that the implementation of ETS significantly

improves corporate social responsibility, regardless of carbon prices. However, only in the high carbon price group does corporate social responsibility exhibit a partial intermediary role between ETS and corporate financial performance.

TABLE VII. Intermediary test results of CSR

VARIABLES	Full sample		Low carbon price		High carbon price	
	CSR	*Roa*	*CSR*	*Roa*	*CSR*	*Roa*
DID	0.099*** (4.43)	0.005** (2.56)	0.094*** (3.00)	0.004 (1.42)	0.104*** (2.97)	0.005* (1.90)
CSR		0.003*** (2.65)		0.004* (1.90)		0.003* (1.89)
Constant	-0.062 (-0.36)	-0.090*** (-5.97)	-0.417 (-1.62)	-0.092*** (-3.86)	0.215 (0.92)	-0.091*** (-4.65)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	5,199	5,199	2253	2253	2946	2946
Adj-R^2	0.090	0.329	0.102	0.308	0.064	0.334

V. Conclusions

Based on an analysis of data from A-share listed companies in the Shanghai and Shenzhen markets between 2009 and 2020, this study explores the impact of ETS on corporate financial performance and its influence mechanisms using the PSM-DID. The results reveal several key findings: Firstly, the implementation of the ETS has a favorable influence on corporate financial performance, demonstrating a continuous and long-term impact. Secondly, when considering the carbon price grouping sample, the positive impact of the ETS on corporate financial performance is observed only in the high carbon price group, and the relationship is positive but insignificant in the low carbon group. Lastly, the study sheds light on the influence mechanisms by revealing that the ETS promotes corporate financial performance through its facilitation of corporate green innovation and enhancement of corporate social responsibility. Importantly, this effect is found to be significant exclusively in the high carbon price group.

Given the findings of the above study, the following policy recommendations are proposed: Firstly, the government and the market collaborate to vigorously promote carbon market trading. Although the official launch of China's nationwide unified carbon trading market in 2021 has been significant in boosting trading activity, the current participation of industries and corporations in carbon emission trading is limited and insufficient. Therefore, the government should employ incentive measures to encourage the diversification of carbon products and increase corporate participation in market trading through policy promotion and demand generation. Secondly, we advised to establish a reasonable overall quantity of carbon emission allowances. Its determination has a direct impact on the dynamics of supply and demand for carbon allowances. Setting the total allowances significantly higher than the actual carbon emissions would result in low carbon prices and insufficient motivation for corporations to reduce emissions, rendering the effectiveness of the ETS ineffective. Therefore, it is essential to establish an appropriate amount of carbon quotas, leveraging the market operation mechanism of carbon pricing to stimulate green innovation among corporations, enhancing their social responsibility, and achieving long-term sustainable development. Thirdly, as key participants in the ETS, corporations must embrace their corresponding social responsibility by proactively undertaking green transformation and upgrading. Under the constraining framework of the ETS, corporations have the opportunity both to enhance their public image by assuming social responsibility and drive sustainable development by applying green technology upgrades and transformation, and then enhance their financial performance and competitiveness.

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