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Carbon Emission Trading and Corporate Financing: Evidence from China

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Abstract: As an important tool to control CO_2 emission, carbon emission trading (CET) has been highlighted in prior studies for its positive effects on firms. However, we are concerned about the role of the CET in corporate financing. Through a quasi-natural experiment from China's CET pilot, regarded as the start-up stage of China's emission trading system, we investigate the manufacturing corporate financing (i.e., debt and commercial credit financing). The results show that the firms in China's CET market have less debt financing. Additionally, in the heterogeneity analysis, we found that (1) the CET is negatively related to corporate financing when their financing constraints are weak, whereas it only reduces long-term debt for the firms with strong financing constraints. (2) The impact of the CET on corporate financing is not significant for the firms located in first-tier cities in China, but in other cities, the CET negatively influences firms' long-term debt and contributes to commercial credit financing. (3) The CET only plays a negative role in long-term debt and a positive role in commercial credit financing for firms in high energy-consuming industries. This study enlightens the government to improve the emission trading system and increase financing support to manufacturing firms in the CET market.

Keywords: carbon emission trading; corporate financing; manufacturing firm

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1. Introduction

Climate warming is a global environmental problem that is rooted in excessive emissions of greenhouse gases such as CO_2. It is predicted that from 2010 to 2030, the global net human-induced CO_2 emissions need to be reduced by about 45% and reach "net-zero" emissions around 2050 to limit global warming to 1.5 °C [1]. In recent years, many countries have formulated various policies to reduce CO_2 emissions. The CET system is a cap-and-trade model in which the authority sets the number of certificates to be offered to the market based on a specific emissions target [2]. Firms in the CET market can not only take various measures to reduce their carbon emissions but also choose to purchase quotas from the market to offset excess emissions. As an efficient and low-cost carbon emission reduction tool, the CET system was gradually adopted by various countries [3]. At present, the main international CET markets include the EU Emissions Trading System (EU-ETS), the Regional Greenhouse Gas Initiative (RGGI) in the United States, California's Cap-and-Trade Program, the Tokyo Cap-and-Trade Program, the New Zealand Emissions Trading Scheme, South Korea's carbon trading program, and China's Carbon Emission Trading Market [4,5].

Since China's reform and opening up, its rapid economic development has brought a huge environmental cost, and China's greenhouse gas emissions are the highest in the world. To actively assume the responsibility for major powers, in 2020, Chinese President Xi Jinping announced at the 75th session of the United Nations General Assembly that China aims to achieve carbon peaking by 2030 and carbon neutrality by 2060. The Chinese government

has made various attempts to reduce carbon emissions, and the CET market is one of the most representative events. As the CET market can play the role of the market mechanism, it can effectively reduce the financial pressure on the government and achieve the carbon emission reduction target at the lowest economic cost [6]. Meanwhile, the construction of the CET market reflects the transformation of China's climate change policies from mainly relying on administrative measures and financial subsidies to carbon pricing. From 2013 to 2014, China's seven CET pilots, Shenzhen, Shanghai, Beijing, Guangdong, Tianjin, Hubei, and Chongqing, opened their CET markets one after another. In 2016, the eighth CET pilot, the Fujian CET market, was opened. The pilot CET market in China has been regarded as the start-up stage of China's emission trading system and also needs to be strengthened [4].

Prior studies were conducted to evaluate the CET from different perspectives, such as assessing the system design of the CET market [7–9], the impact of the CET market on carbon emission reduction [10–12], and the effect of the CET on firm value and technological innovation [13,14]. However, it is not clear whether the CET market will have an impact on corporate financing. The purpose of the CET market is to reduce carbon emissions, with firms being the main contributors to carbon emission reduction. It was shown that green technological innovation is an effective way to reduce CO_2 emissions [15,16]. However, technological innovation faces the challenges of high cost, long cycle time, and high risk [17]. Therefore, the green technological innovation activities of firms need sufficient financial support. However, China's firms generally have poor financing capability and high financing costs [18]. When firms face strong financing constraints, they usually sacrifice environmental benefits to invest in projects with quicker results [19]. Thus, financing constraints can hinder the green transformation of firms' production methods [20] and discourage them from achieving carbon emission reduction. Given that corporate financing has a direct impact on carbon emission reduction, it is necessary to investigate the effect of the CET on corporate financing. Since the environmental regulatory policies increase the environmental risk of firms, especially the credit risk [21], it will be more difficult for firms to obtain financing. However, few studies have examined the impact of the CET market on corporate financing.

This paper aims to explore the impact of the CET on corporate financing. We divided corporate financing into debt financing and commercial credit financing and further subdivided debt financing into long-term debt and short-term debt financing, which contributes to creatively clarifying the role of the CET on corporate financing structure. Taking China's CET pilot in 2013 as a quasi-natural experiment, we used the Difference-in-Differences (DID) method to investigate the impact of the CET on manufacturing corporate financing. We found that the CET has a significant effect on corporate financing. Our findings are expected to provide evidence for whether the CET negatively affects corporate financing in a defective market. This study not only contributes to the literature on the impact of the CET but also provides references for government to further improve the CET system for carbon peaking and carbon neutrality.

The paper is further organized as follows. Section 2 presents the literature review and our hypothesis, and Section 3 provides the model, variables, and data. Then, Section 4 shows the empirical results. Section 5 discusses our main findings and provides the policy implications, limitations, and future studies.

2. Literature Review and Hypothesis Development

The CET market aims to reduce carbon emissions and is an effective policy tool for achieving carbon neutrality [22]. Since the start of the CET market, many studies have discussed the system design and impact of the CET market. The low carbon price is a common problem in the CET markets in different countries. There are various reform options for low carbon prices in the EU-ETS, such as adjusting the cap, adding fixed and variable carbon taxes to the ETS, setting an auction reserve price, etc. [7]. Setting a carbon price floor is one of the effective ways to stabilize the price of allowances [23]. To

improve the effectiveness of the EU-ETS, Clò et al. (2013) [8] compare various policies and finally find that the reversible adjustment of the ETS cap by the carbon central bank is the optimal option. Similarly, China's CET market also suffers from distorted carbon trading prices [24], resulting in undermining carbon emission reduction [25]. As China's CET market is in its infancy, it has deficient basic technical conditions, a high policy sensitivity, an indefinite reward and punishment mechanism, and many restrictions on trading participants, resulting in low market efficiency [9]. In addition, China's CET market also has some challenges, such as a lack of a functional carbon trading market, inaccuracy in quota allocation, imperfect trading mechanism, and lagging legislation [26].

Another piece of the literature focuses on evaluating the impact of the CET market. Some studies show that the CET market can reduce CO_2 emissions [10–12], which not only effectively enhances the green production performance [6] but also improves green development efficiency [27]. The construction of the CET market also contributes to the green total factor productivity of pilot provinces and reduces investment in carbon-intensive industries to promote regional carbon equality [28]. The CET market was also proved to have an employment double dividend effect, which can effectively expand the scale of employment [29]. At the micro-level, prior studies examine the impact of the CET market on firms. For instance, the CET market is confirmed to improve firm value by capturing cash incomes [30], but there is a negative relationship between allocation shortfalls and firm value [13]. Additionally, firms are motivated by the CET market to strengthen their innovation ability, especially low-carbon technological innovation [14], where both high carbon trading prices and high price volatility can promote firm innovation [31]. However, it was also pointed out that CET does not enhance firm green innovation, mainly due to the reduction in expected cash income and revenue for firms, which results in corporate lower production to reduce carbon emissions [3]. Furthermore, the CET market internalizes the reduction costs of the firms involved and reduces the investment scale of firms in pilot regions [32].

As firms are the main participators of carbon trading in the CET market, exploring the impact of the CET market on firms benefits the system design. The prior studies provided many references to obtain knowledge of the CET market, but we do not know the effect of the CET on participators' financing activities. Considering corporate financing has a great impact on carbon emission reduction because firms have to increase investments in low carbon activities, such as green technological technology [14], it is necessary to test whether the CET market contributes to corporate financing. As a result, we performed a DID estimation to investigate the effect of China's CET on corporate financing.

We believe the CET market maybe play a negative role in corporate financing. It was shown that environmental regulatory pressure has a negative impact on corporate financing [33]. The implementation of environmental policies increases the credit risk of firms [21], and as a result, banks also charge higher interest rates for loans to firms facing more stringent environmental regulations [34]. The CET is a core environmental policy tool to achieve carbon peak and carbon neutrality goals, so the launch of the CET market may increase the credit risk of firms as participators and adversely affect their financing. Most participants in China's CET pilot are high-emission firms, which indicates the entry of firms into the CET pilot list could send environmental risk signals to creditors. Then creditors may assess the operation uncertainties of the pilot firms in the future, such as a potential risk that the loans will not be retrieved in full and on time [35]. Although the pilot of China's CET market aims to motivate firms to reduce carbon emissions, prior studies found that pilot firms are more likely to achieve carbon emissions reduction by reducing production [3]. The production limitation decreases the cash income and expected profit for firms, which increases the risk of creditors providing financing for firms in the CET market. Our assumption appears in a defective CET market where firms hardly cover the costs of carbon emission reduction through capturing cash income from carbon emission trading because the carbon price is low and firms lack strong motivation for carbon emission

trading. As a result, the firms as participants in a defective CET market have less financing. In summary, we proposed the following hypothesis:

Hypothesis: The CET has a negative impact on corporate financing.

3. Methods

3.1. Model and Variable

The DID method is widely used in the research of policy evaluation, as well as in the papers evaluating the impact of the CET market [6,11,12,28]. China's CET pilot since 2013 can be regarded as a quasi-natural experiment. Referring to the research of Chen et al. (2021) [3] and Zhang and Wang (2021) [32], we adopted the DID method to investigate the effect of the CET on corporate financing. Considering the inconsistent start-up times of the eight pilots, we conducted the following multi-phase DID model (1):

$$Financing_{it} = \alpha_0 + \alpha_1 Treatpost_{it} + \alpha_2 X_{it} + \theta_i + \gamma_t + \varepsilon_{it} \quad (1)$$

In Equation (1), i represents firm and t indexes year, respectively. The dependent variable $Financing_{it}$ indicates the financing activities of firm i in year t, including debt financing and commercial credit financing, in which debt financing includes long-term debt and short-term debt. $Treatpost_{it} = Treat_i \times Post_{it}$, is the core explanatory variable, which is the interaction of the treatment variable and time variable. $Treat_i$ is a dummy variable equal to 1 for the experimental group sample and 0 for the control group. $Post_{it}$ is a time dummy variable. Since the start of the CET market in the eight pilot areas is not consistent, with Shenzhen, Shanghai, Beijing, Guangdong, and Tianjin in 2013, Hubei and Chongqing in 2014, and Fujian in 2016. Therefore, $Post_{it} = 1$ when firm i is in one of the four pilot areas of Shenzhen, Shanghai, Beijing, and Guangdong (except Shenzhen) and $t \geq 2013$, or when firm i is in Hubei or Chongqing and $t \geq 2014$, or when firm i is in Fujian and $t \geq 2016$; otherwise, $Post_{it} = 0$. X_{it} is a group of control variables, θ_i is the firm fixed effect, γ_t is the year fixed effect, and ε_{it} is the residual term.

Following the literature [33,35,36], we controlled for several variables that may affect firms' financing as follows: asset-liability ratio (Lev), capital intensity (Intensity), firm age (Age), the rate of return on total assets (ROA), firm size (Size), firm growth (Growth), nature of equity (Equity), the proportion of independent directors (Independent), ownership concentration (Concentration), and board activity (Board). All variables are defined in Table 1.

Table 1. Variable Definitions.

Variable	Definition
Debt	(long-term debt + short-term debt)/total assets
L_Debt	Long-term debt divided by total assets
S_Debt	Short-term divided by total assets
Credit	(accounts payable + notes payable + deposit received)/total assets
Treatpost	Treat × Post
Lev	Total liabilities divided by total assets
Intensity	Total assets divided by operating income
Age	The logarithm of the number of years of firm establishment
ROA	Net income divided by total assets
Size	The logarithm of total assets
Growth	Growth rate of total assets
Equity	A dummy variable equal to 1 for state-owned enterprises and 0 otherwise
Independent	Number of independent directors divided by number of directors
Concentration	Percentage of shareholding of the largest shareholder
Board	Number of board meetings

3.2. Data Sources

The production activities of manufacturing firms cause more serious environmental pollution than other firms, and the asset-heavy characteristics of manufacturing firms also have more severe financing pressure [37]. Therefore, we used the data of listed manufacturing firms (A-share) in the eight pilot areas from 2008 to 2019 as our sample. Our sample is divided into two groups: (1) The experimental group, including the listed manufacturing firms in the CET pilot list, and (2) the control group, including the listed manufacturing firms in the pilot areas that are not included in the CET pilot list. The list of listed manufacturing firms participating in the CET pilot was obtained from the websites of the governments of the pilot areas. Since the data of the manufacturing firms listed after the start of the pilot were missing before the pilot, we deleted these sample firms. We collected the data on corporate financing and control variables from the China Stock Market and Accounting Research Database. All data of listed firms with missing values for the current year were excluded, and the continuous variables were winsorized at the upper and lower 1% levels to avoid extreme outliers.

4. Empirical Results

4.1. Descriptive Statistics

Table 2 reports the descriptive statistics for variables. There are 5171 firm-year observations in our sample. The means of *Debt*, *L_Debt*, *S_Debt*, and *Credit* are 0.148, 0.035, 0.112, and 0.189, respectively, indicating a relatively low proportion of long-term debt in the sample firms. The mean of *Treatpost* shows that 10.8% of firm-year observations are affected by the CET market. In terms of firm features, the average asset-liability ratio, capital intensity, and ROA are 0.406, 2.126, and 0.038. On average, *Equity* is 0.366, showing that 36.6% of samples are state-owned enterprises. In addition, other variables are within a reasonable value range.

Table 2. Descriptive Statistics.

Variables	N	Mean	SD	Min	P25	Median	P75	Max
Debt	5171	0.148	0.147	0	0.015	0.109	0.239	0.617
L_Debt	5171	0.035	0.066	0	0	0	0.043	0.351
S_Debt	5171	0.112	0.118	0	0.008	0.078	0.176	0.514
Credit	5171	0.189	0.144	0.007	0.082	0.149	0.259	0.698
Treatpost	5171	0.108	0.310	0	0	0	1	1
Lev	5171	0.406	0.212	0.039	0.236	0.401	0.555	0.959
Intensity	5171	2.126	1.474	0.383	1.220	1.724	2.573	9.565
Age	5171	2.680	0.469	1.099	2.398	2.773	2.996	3.497
ROA	5171	0.038	0.068	−0.295	0.014	0.039	0.068	0.217
Size	5171	21.956	1.291	19.103	21.055	21.794	22.630	25.985
Growth	5171	0.221	0.494	−0.362	0.009	0.094	0.234	3.137
Equity	5171	0.366	0.482	0	0	0	1	1
Independent	5171	0.378	0.056	0.333	0.333	0.364	0.429	0.571
Concentration	5171	0.346	0.149	0.081	0.232	0.319	0.449	0.740
Board	5171	9.750	3.669	4	7	9	12	23

Note: The descriptive statistical results of the variables are reported in the table, which includes observations (N), mean, standard deviation (SD), minimum (Min), first quartile (P25), and third quartile (P75), and maximum (Max).

4.2. Baseline Results

Table 3 reports the regression results for the influence of the CET on corporate financing. According to columns (1) and (2), the coefficients of *Treatpost* are all negative and significant at the 5% level. This supports our hypothesis, indicating that the CET has a negative impact on debt financing for pilot manufacturing firms, especially long-term debt. However, based on the estimates in columns (3) and (4), the coefficients of *Treatpost* are all insignificant,

which means the CET plays no significant role in short-term debt and commercial credit financing of pilot manufacturing firms.

Table 3. Regression results of baseline models.

Variables	*Debt* (1)	*L_Debt* (2)	*S_Debt* (3)	*Credit* (4)
Treatpost	−0.024 ** (0.011)	−0.017 ** (0.007)	−0.007 (0.009)	0.001 (0.007)
Lev	0.504 *** (0.029)	0.098 *** (0.015)	0.392 *** (0.025)	0.266 *** (0.023)
Intensity	0.000 (0.004)	0.005 ** (0.002)	−0.006 ** (0.003)	−0.021 *** (0.003)
Age	0.000 (0.020)	0.005 (0.010)	−0.006 (0.017)	−0.013 (0.017)
ROA	0.041 (0.041)	0.023 (0.018)	0.014 (0.034)	0.113 *** (0.035)
Size	0.022 ** (0.010)	0.019 *** (0.005)	0.003 (0.007)	0.010 (0.006)
Growth	0.048 *** (0.005)	0.009 *** (0.002)	0.037 *** (0.004)	0.093 *** (0.005)
Equity	−0.033 (0.023)	0.005 (0.011)	−0.037 ** (0.017)	0.012 (0.016)
Independent	0.072 (0.050)	0.017 (0.028)	0.064 (0.044)	0.024 (0.050)
Concentration	0.003 (0.049)	0.050 (0.034)	−0.060 * (0.036)	−0.027 (0.037)
Board	0.001 * (0.001)	−0.000 (0.000)	0.002 *** (0.001)	−0.001 ** (0.001)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	5171	5171	5171	5171
R^2	0.737	0.578	0.692	0.790
Constant	−0.576 *** (0.193)	−0.417 *** (0.096)	−0.142 (0.141)	−0.051 (0.123)

Note: Standard error clustered at the firm level is presented in the parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

4.3. Robustness Test

4.3.1. Parallel Trend Test

It is necessary to test parallel trends for an independent variable between the experimental and the control groups before the policy [38]. Referring to Jacobson et al. (1993) [39], we adopted the event study method to examine parallel trends. We conducted the interaction items of year dummy and *Treat*. The regression results for each interaction item, including coefficients and confidence intervals, are given in Figure 1. The results show that the coefficients of interaction items before 2013 are insignificant, indicating the parallel trend assumption is fulfilled.

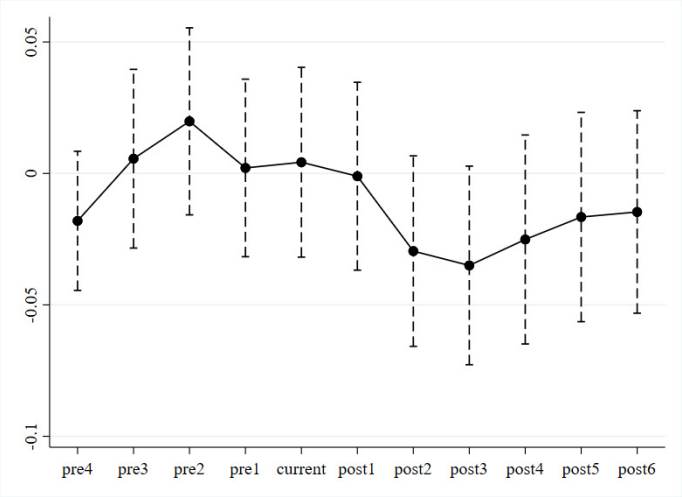

Figure 1. Results of testing parallel trend.

4.3.2. PSM-DID

We used the propensity score matching DID (PSM-DID) method to address the endogeneity issue due to omitted variables. Control variables in this study as covariates were applied to evaluate propensity scores through logistic regression. The results are shown in Table 4, indicating that the CET significantly and negatively affects debt financing, only including long-term debt financing. However, the CET has no significant impact on short-term debt financing and commercial credit financing. Therefore, the results show that the baseline results are not affected by the omission of unobserved factors.

Table 4. The results of PSM-DID.

Variables	*Debt* (1)	*L_Debt* (2)	*S_Debt* (3)	*Credit* (4)
Treatpost	−0.023 **	−0.016 **	−0.006	0.002
	(0.011)	(0.007)	(0.009)	(0.007)
Controls	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	4861	4861	4861	4861
R^2	0.761	0.596	0.719	0.808
Constant	−0.409 **	−0.393 ***	−0.011	0.129
	(0.173)	(0.096)	(0.138)	(0.115)

Note: Standard error clustered at the firm level is presented in the parentheses. *** and ** indicate statistical significance at the 1% and 5% levels, respectively.

4.3.3. Control the Impact of Other Policy

Since the DID method depends on the temporal and spatial changes of policies, the results may be biased if there are other relevant policies around the time of the CET market launch. China's government announced three pilot lists of low-carbon cities in 2010, 2012, and 2017, respectively. Therefore, we constructed the annual dummy variable LCC_{it} of the policy. When the city to which firm i belongs was included in the pilot list of low-carbon cities, the LCC_{it} of the firm in that year and subsequent years was assigned as 1; otherwise, it was assigned as 0. LCC_{it} and the interaction item $Treat_{it} \times LCC_{it}$ were put into the model for re-estimation to control the impact of the low-carbon city pilot policy on our model. As shown in Table 5, the coefficients of *Treatpost* are negative and significant in columns (1) and (2), while the coefficients of *Treatpost* are both insignificant in

columns (3) and (4). The results show that the baseline results are not affected by the low carbon city pilot policy.

Table 5. Control the impact of the low-carbon city pilot policy.

Variables	*Debt* (1)	*L_Debt* (2)	*S_Debt* (3)	*Credit* (4)
Treatpost	−0.033 ***	−0.020 **	−0.012	0.005
	(0.012)	(0.008)	(0.010)	(0.007)
Treat × *LCC*	0.025 *	0.011	0.013	−0.012
	(0.013)	(0.008)	(0.012)	(0.010)
Controls	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	5171	5171	5171	5171
R^2	0.737	0.578	0.692	0.790
Constant	−0.575 ***	−0.416 ***	−0.142	−0.051
	(0.193)	(0.095)	(0.141)	(0.123)

Note: Standard error clustered at the firm level is presented in the parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

4.3.4. Alternative Estimation Methods

Because the dependent variables left truncated characteristics, we used Tobit regression to retest the relationship between the CET and corporate financing. The results reported in Table 6 show that the coefficients remain significantly negative for *Treatpost* in columns (1) and (2) but are insignificant for *Treatpost* in columns (3) and (4). The results presented in Table 6 are consistent with the main conclusion, which further proves that the DID regression results of the CET on corporate financing are robust.

Table 6. The results of Tobit Regression.

Variables	*Debt*	*L_Debt*	*S_Debt*	*Credit*
	(1)	(2)	(3)	(4)
Treatpost	−0.027 **	−0.022 **	−0.010	0.001
	(0.012)	(0.010)	(0.010)	(0.007)
Controls	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	5171	5171	5171	5171
R^2	—	—	—	—
Constant	−0.854 ***	−0.890 ***	−0.424 ***	−0.051
	(0.208)	(0.149)	(0.155)	(0.117)

Note: Standard error clustered at the firm level is presented in the parentheses. *** and ** indicate statistical significance at the 1% and 5% levels, respectively.

4.4. Heterogeneity Analysis

We further tested the heterogeneity of the impact of the CET on corporate financing. First of all, the level of the firm's financing constraints before entering the CET market may have an impact on corporate financing, so we retested the results using strong and weak financing constraints subsamples. Referring to previous studies [40], we used the KZ index to measure financing constraints. The larger the KZ index, the higher the degree of financing constraints faced by firms. We calculated the KZ index for the sample firms in the year before entering the CET market and divided them into two subsamples based on

the median of this index. The testing results are shown in panel A of Table 7, indicating that the CET negatively affects debt financing and commercial credit financing for pilot manufacturing firms with weak financing constraints, and for others with strong financing constraints, only long-term debt is negatively influenced by the CET.

Table 7. The results of the heterogeneity test.

Panel A: Heterogeneity of Financing Constraints								
Variables	**Strong Financing Constraints**				**Weak Financing Constraints**			
	Debt	***L_Debt***	***S_Debt***	***Credit***	***Debt***	***L_Debt***	***S_Debt***	***Credit***
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Treatpost	−0.017	−0.017 *	−0.012	0.148	−0.026 *	−0.010	−0.015	−0.019 *
	(0.015)	(0.010)	(0.014)	(0.009)	(0.014)	(0.007)	(0.013)	(0.011)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2675	2675	2675	2675	2434	2434	2434	2434
R^2	0.716	0.589	0.675	0.803	0.712	0.503	0.670	0.792
Constant	−0.602 **	−0.508 ***	−0.083	0.066	−0.292	−0.180	−0.095	−0.178
	(0.251)	(0.128)	(0.187)	(0.147)	(0.305)	(0.122)	(0.249)	(0.224)
Panel B: Heterogeneity of City Hierarchies								
Variables	**First-Tier Cities**				**Other Cities**			
	Debt	***L_Debt***	***S_Debt***	***Credit***	***Debt***	***L_Debt***	***S_Debt***	***Credit***
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Treatpost	−0.010	−0.005	−0.006	−0.009	−0.108 ***	−0.091 ***	−0.012	0.038 **
	(0.011)	(0.005)	(0.010)	(0.008)	(0.031)	(0.024)	(0.028)	(0.017)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3256	3256	3256	3256	1915	1915	1915	1915
R^2	0.732	0.608	0.690	0.791	0.750	0.571	0.691	0.794
Constant	−0.700 **	−0.376 ***	−0.272	−0.020	−0.397	−0.372 **	−0.030	−0.173
	(0.270)	(0.114)	(0.186)	(0.166)	(0.314)	(0.170)	(0.269)	(0.246)
Panel C: Heterogeneity of Energy-Consuming Industries								
Variables	**High Energy-Consuming Industries**				**Non-High Energy-Consuming Industries**			
	Debt	***L_Debt***	***S_Debt***	***Credit***	***Debt***	***L_Debt***	***S_Debt***	***Credit***
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Treatpost	−0.043	−0.046 ***	0.004	0.028 *	−0.011	−0.002	−0.009	−0.009
	(0.026)	(0.017)	(0.020)	(0.014)	(0.011)	(0.005)	(0.011)	(0.009)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1056	1056	1056	1056	4115	4115	4115	4115
R^2	0.094	0.606	0.691	0.722	0.743	0.581	0.688	0.806
Constant	−0.383	−0.422	0.103	−0.028	−0.646 ***	−0.424 ***	−0.216	−0.129
	(0.601)	(0.362)	(0.301)	(−0.028)	(0.162)	(0.075)	(0.157)	(0.136)

Note: Standard error clustered at the firm level is presented in the parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Secondly, the level of urban economic development may have an impact on the effect of the CET on corporate financing. In China, the first-tier cities, including Beijing, Shanghai, Shenzhen, and Guangzhou, have more developed economies than other cities, and corporate financing may be relatively less negatively affected by the CET. We divided samples into sub-samples of first-tier cities and other cities according to the cities in which firms are located. Panel B of Table 7 reports the results of city hierarchy heterogeneity. The results show that when pilot manufacturing firms are located in first-tier cities, the effect of the CET on corporate financing is not significant. However, the CET has a negative impact on debt financing and the long-term debt of pilot manufacturing firms in non-first-tier cities and positively affects commercial credit financing.

Thirdly, panel C of Table 7 reports the results of examining the heterogeneity of energy-consuming industries. Although there are many industries involved in the pilot of the CET market, and even some service industries with high carbon emissions are included in Beijing and Shanghai, high energy-consuming industries such as petrochemicals, chemicals, building materials, iron and steel, nonferrous metals, paper making, power, and aviation are the main industries for carbon trading [4]. Therefore we divided the samples into high energy-consuming industries and non-high energy-consuming industries subsamples for retesting. As shown in panel C of Table 7, the CET has a negative influence on the long-term debt of the pilot manufacturing firms in the high energy-consuming industries and positively affects commercial credit financing. However, the CET plays no significant role in the corporate financing of pilot manufacturing firms in non-high energy-consuming industries.

5. Conclusions and Discussion

5.1. Conclusions

Since corporate financing can play a significant role in their carbon reduction activities, such as fund support for low-carbon innovation, it is necessary to explore the impact of the CET on corporate financing. We divided corporate financing into debt financing and commercial credit financing and further subdivided debt financing into long-term debt and short-term debt. This division helped us to clarify the effect mechanism of the CET on corporate financing and contributes to policy implications for improving the system design of the CET market.

The pilot of the CET market is an important measure for the Chinese government to reduce carbon emissions. Taking the CET pilot in China as a quasi-natural experiment, we performed the DID estimation to investigate the impact of the CET on corporate financing. We found that the debt financing of pilot manufacturing firms is negatively affected by the CET, especially long-term debt, but the short-term debt and commercial credit financing are not affected by the CET. In the heterogeneity analysis, we found that: (1) The CET has a significantly negative impact on debt financing and commercial credit financing of pilot manufacturing firms with weak financing constraints simultaneously, but only on long-term debt of firms with strong financing constraints. (2) The CET has no significant impact on the corporate financing of pilot manufacturing firms in first-tier cities. In other cities, we found that the CET negatively affects debt financing of pilot manufacturing firms, especially long-term debt, but plays a positive role in commercial credit financing simultaneously. (3) The CET plays a negative role in the long-term debts of the pilot manufacturing firms in high energy-consuming industries. Meanwhile, the effect of the CET on commercial credit financing is significantly positive. However, the CET has no significant impact on the corporate financing of pilot manufacturing firms in non-high energy-consuming industries.

5.2. Discussion

Our results indicated that after the pilot manufacturing firms entered the CET market, the creditors received an environmental risk signal and then tightened the loans to these firms. Therefore it is more difficult for firms in the CET market to obtain debt financing. The results also show that the CET has changed the debt financing maturity structure of pilot manufacturing firms and shortened their debt financing maturity. Compared with short-term debt, long-term debt has a longer cycle. Thus, the creditors take a more cautious attitude toward the debt financing of firms in the CET market.

According to the results of heterogeneity analysis, the findings are as follows:

(1) As it is hard for firms with strong financing constraints to obtain financing before the launch of the CET market, in reality, the CET has less effect on their financing, resulting in difficulties for them in obtaining long-term debt. On the contrary, firms with weak financing constraints originally had fewer difficulties in obtaining financing. However, when those firms enter the CET market, the creditors increase their concerns about the cash

income uncertainty of firms because carbon emission reduction limits corporate production. As a result, corporate financing is negatively influenced by the CET for those firms with weak financial constraints;

(2) Prior study has shown that the CET market is more developed in first-tier cities compared to non-first-tier cities in China [41]. Pilot manufacturing firms in first-tier cities can generate revenue through CET, thus effectively covering the cost of carbon emission reduction, which results in no significant relation between the CET and corporate financing. In contrast, the pilot manufacturing firms in non-first-tier cities hardly offset their carbon reduction costs through CET because of the low carbon price, which limits them from obtaining debt financing from the creditors, such as banks. However, commercial credit financing, as a form of inter-firm financing with the advantages of more convenient financing, lower cost, and fewer restrictions than debt financing, contributes to corporate financing for pilot manufacturing firms. Therefore, the CET increases commercial credit financing of pilot manufacturing firms;

(3) Due to more environmental risks of firms in high energy-consuming industries after they enter the CET market, creditors have a poor willingness to provide long-term debt to pilot manufacturing firms. Moreover, as firms in high energy-consuming industries have more pressure on carbon emission reduction, they hardly achieve carbon emission reduction targets only through the CET and also need to obtain more funds to support their low-carbon activities. As it is difficult for firms to obtain debt financing, pilot manufacturing firms may prefer commercial credit financing that is more convenient for firms to obtain.

5.3. Policy Implications

Our research provides the following policy implications: (1) Policymakers should continuously improve the CET market system. As the CET market pilots are the initial stage in China's CET system, there are some problems such as inaccurate allocation of allowances and distorted carbon trading prices [25]. In a defective CET market, it is difficult to compensate carbon emission reduction costs through CET for pilot firms, which results in reducing production to achieve the low-carbon target. Therefore, policymakers should set a reasonable price for carbon allowances, which can motivate firms to participate in the CET market. Then, the liquidity of carbon trading also is improved. As a result, it is necessary to introduce a variety of measures to further activate the CET market and improve the system of the CET market. (2) The government should introduce relevant policies to encourage banks and other financial institutions to increase financing support for the CET pilot firms, especially long-term loans. Low-carbon technology innovation is one of the most important ways for the pilot firms to reduce carbon emissions, which requires amounts of financial support. Moreover, due to the long cycle of low-carbon technology innovation, firms hardly recover their funds in the short term, and long-term loans are more beneficial in reducing the financial pressure on pilot firms. Therefore, banks and other financial institutions should increase their financial support to the CET pilot firms to contribute to carbon emission reduction.

5.4. Limitations and Future Studies

The main limitations of our study are as follows: (1) We studied the impact of the CET on corporate financing but have yet to empirically test its specific effect mechanism. In the future, scholars can further debate the impact of CET prices and market liquidity on corporate financing in-depth to clarify the effect mechanism of the CET on corporate financing. (2) Our study finds that the CET has a negative impact on corporate financing, but does corporate financing further impact firm innovation and performance? This question needs to be further explored.

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References

1. Intergovernmental Panel on Climate Change (IPCC). *Global Warming of 1.5 °C: An IPCC Special Report on the Impacts of Global Warming of 1.5 °C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*; Intergovernmental Panel on Climate Change: Geneva, Switzerland, 2018. Available online: https://www.ipcc.ch/sr15/ (accessed on 10 April 2022).
2. Bersani, A.M.; Falbo, P.; Mastroeni, L. Is the ETS an Effective Environmental Policy? Undesired Interaction between Energy-Mix, Fuel-Switch and Electricity Prices. *Energy Econ.* **2022**, *110*, 105981. [CrossRef]
3. Chen, Z.; Zhang, X.; Chen, F. Do Carbon Emission Trading Schemes Stimulate Green Innovation in Enterprises? Evidence from China. *Technol. Forecast. Soc. Chang.* **2021**, *168*, 120744. [CrossRef]
4. Weng, Q.; Xu, H. A Review of China's Carbon Trading Market. *Renew. Sustain. Energy Rev.* **2018**, *91*, 613–619. [CrossRef]
5. Narassimhan, E.; Gallagher, K.S.; Koester, S.; Alejo, J.R. Carbon pricing in practice: A review of existing emissions trading systems. *Clim. Policy* **2018**, *18*, 967–991. [CrossRef]
6. Yang, L.; Li, Y.; Liu, H. Did Carbon Trade Improve Green Production Performance? Evidence from China. *Energy Econ.* **2021**, *96*, 105185. [CrossRef]
7. Brink, C.; Vollebergh, H.R.J.; van der Werf, E. Carbon Pricing in the EU: Evaluation of Different EU ETS Reform Options. *Energy Policy* **2016**, *97*, 603–617. [CrossRef]
8. Clò, S.; Battles, S.; Zoppoli, P. Policy Options to Improve the Effectiveness of the EU Emissions Trading System: A Multi-Criteria Analysis. *Energy Policy* **2013**, *57*, 477–490. [CrossRef]
9. Zhao, X.; Jiang, G.; Nie, D.; Chen, H. How to Improve the Market Efficiency of Carbon Trading: A Perspective of China. *Renew. Sustain. Energy Rev.* **2016**, *59*, 1229–1245. [CrossRef]
10. Ellerman, A.D.; Buchner, B.K. Over-Allocation or Abatement? A Preliminary Analysis of the EU ETS Based on the 2005–06 Emissions Data. *Environ. Resour. Econ.* **2008**, *41*, 267–287. [CrossRef]
11. Dong, F.; Dai, Y.; Zhang, S.; Zhang, X.; Long, R. Can a Carbon Emission Trading Scheme Generate the Porter Effect? Evidence from Pilot Areas in China. *Sci. Total Environ.* **2019**, *653*, 565–577. [CrossRef]
12. Dong, Z.-Q.; Wang, H.; Wang, S.-X.; Wang, L.-H. The Validity of Carbon Emission Trading Policies: Evidence from a Quasi-Natural Experiment in China. *Adv. Clim. Chang. Res.* **2020**, *11*, 102–109. [CrossRef]
13. Brouwers, R.; Schoubben, F.; Van Hulle, C.; Van Uytbergen, S. The Initial Impact of EU ETS Verification Events on Stock Prices. *Energy Policy* **2016**, *94*, 138–149. [CrossRef]
14. Calel, R.; Dechezlepretre, A. Environmental Policy and Directed Technological Change: Evidence from the European Carbon Market. *Rev. Econ. Stat.* **2016**, *98*, 173–191. [CrossRef]
15. Obobisa, E.S.; Chen, H.; Mensah, I.A. The Impact of Green Technological Innovation and Institutional Quality on CO_2 Emissions in African Countries. *Technol. Forecast. Soc. Chang.* **2022**, *180*, 121670. [CrossRef]
16. Ma, Q.; Murshed, M.; Khan, Z. The Nexuses between Energy Investments, Technological Innovations, Emission Taxes, and Carbon Emissions in China. *Energy Policy* **2021**, *155*, 112345. [CrossRef]
17. Liu, X.; Jiang, S. Bank Equity Connections, Intellectual Property Protection and Enterprise Innovation—A Bank Ownership Perspective. *China J. Account. Res.* **2016**, *9*, 207–233. [CrossRef]
18. Song, Z.; Storesletten, K.; Zilibotti, F. Growing Like China. *Am. Econ. Rev.* **2011**, *101*, 196–233. [CrossRef]
19. Banerjee, A.V.; Duflo, E. Giving Credit Where It Is Due. *J. Econ. Perspect.* **2010**, *24*, 61–79. [CrossRef]
20. Yu, L.; Zhang, B.; Yan, Z.; Cao, L. How Do Financing Constraints Enhance Pollutant Emissions Intensity at Enterprises? Evidence from Microscopic Data at the Enterprise Level in China. *Environ. Impact Assess. Rev.* **2022**, *96*, 106811. [CrossRef]
21. Raimo, N.; Caragnano, A.; Zito, M.; Vitolla, F.; Mariani, M. Extending the Benefits of ESG Disclosure: The Effect on the Cost of Debt Financing. *Corp. Soc. Responsib. Environ. Manag.* **2021**, *28*, 1412–1421. [CrossRef]

22. Chen, X.; Lin, B. Towards Carbon Neutrality by Implementing Carbon Emissions Trading Scheme: Policy Evaluation in China. *Energy Policy* **2021**, *157*, 112510. [CrossRef]
23. Hintermayer, M. A Carbon Price Floor in the Reformed EU ETS: Design Matters! *Energy Policy* **2020**, *147*, 111905. [CrossRef] [PubMed]
24. Wu, L. How Can Carbon Trading Price Distortion Be Corrected? An Empirical Study from China's Carbon Trading Pilot Markets. *Environ. Sci. Pollut. Res.* **2021**, *28*, 66253–66271. [CrossRef] [PubMed]
25. Lin, B.; Jia, Z. Impacts of Carbon Price Level in Carbon Emission Trading Market. *Appl. Energy* **2019**, *239*, 157–170. [CrossRef]
26. Liu, L.; Chen, C.; Zhao, Y.; Zhao, E. China's Carbon-Emissions Trading: Overview, Challenges and Future. *Renew. Sustain. Energy Rev.* **2015**, *49*, 254–266. [CrossRef]
27. Zhu, B.; Zhang, M.; Huang, L.; Wang, P.; Su, B.; Wei, Y.-M. Exploring the Effect of Carbon Trading Mechanism on China's Green Development Efficiency: A Novel Integrated Approach. *Energy Econ.* **2020**, *85*, 104601. [CrossRef]
28. Zhang, S.; Wang, Y.; Hao, Y.; Liu, Z. Shooting Two Hawks with One Arrow: Could China's Emission Trading Scheme Promote Green Development Efficiency and Regional Carbon Equality? *Energy Econ.* **2021**, *101*, 105412. [CrossRef]
29. Yang, X.; Jiang, P.; Pan, Y. Does China's Carbon Emission Trading Policy Have an Employment Double Dividend and a Porter Effect? *Energy Policy* **2020**, *142*, 111492. [CrossRef]
30. Oestreich, A.M.; Tsiakas, I. Carbon Emissions and Stock Returns: Evidence from the EU Emissions Trading Scheme. *J. Bank. Financ.* **2015**, *58*, 294–308. [CrossRef]
31. Lv, M.; Bai, M. Evaluation of China's Carbon Emission Trading Policy from Corporate Innovation. *Financ. Res. Lett.* **2021**, *39*, 101565. [CrossRef]
32. Zhang, Y.J.; Wang, W. How Does China's Carbon Emissions Trading (CET) Policy Affect the Investment of CET-Covered Enterprises? *Energy Econ.* **2021**, *98*, 105224. [CrossRef]
33. Chen, Z.; Yin, M.; Zhou, M. Does Environmental Regulatory Pressure Affect Corporate Debt Financing? *Resour. Conserv. Recycl.* **2022**, *184*, 106405. [CrossRef]
34. Fard, A.; Javadi, S.; Kim, I. Environmental Regulation and the Cost of Bank Loans: International Evidence. *J. Financ. Stab.* **2020**, *51*, 100797. [CrossRef]
35. Shi, J.; Yu, C.; Li, Y.; Wang, T. Does Green Financial Policy Affect Debt-Financing Cost of Heavy-Polluting Enterprises? An Empirical Evidence Based on Chinese Pilot Zones for Green Finance Reform and Innovations. *Technol. Forecast. Soc. Chang.* **2022**, *179*, 121678. [CrossRef]
36. Xu, X.; Li, J. Asymmetric Impacts of the Policy and Development of Green Credit on the Debt Financing Cost and Maturity of Different Types of Enterprises in China. *J. Clean. Prod.* **2020**, *264*, 121574. [CrossRef]
37. Xu, Y.; Li, S.; Zhou, X.; Shahzad, U.; Zhao, X. How Environmental Regulations Affect the Development of Green Finance: Recent Evidence from Polluting Firms in China. *Renew. Energy* **2022**, *189*, 917–926. [CrossRef]
38. Bertrand, M.; Duflo, E.; Mullainathan, S. How Much Should We Trust Differences-in-Differences Estimates? *Q. J. Econ.* **2004**, *119*, 249–275. [CrossRef]
39. Jacobson, L.S.; Lalonde, R.J.; Sullivan, D.G. Earnings Losses of Displaced Workers. *Am. Econ. Rev.* **1993**, *83*, 685–709.
40. Kaplan, S.N.; Zingales, L. Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints? *Q. J. Econ.* **1997**, *112*, 169–215. [CrossRef]
41. Wu, Y.Y.; Qi, J.; Xian, Q.; Chen, J.D. The Carbon Emission Reduction Effect of China's Carbon Market-From the Perspective of the Coordination between Market Mechanism and Administrative Intervention. *CHINA Ind. Econ.* **2021**, *8*, 114–132. (In Chinese) [CrossRef]