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Greening your way to profits: Green strategies and green revenues

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A B S T R A C T

We examine hot-debated but underexplored questions of whether and how green strategies affect corporate green revenues. Using a generalized Difference-in-Differences (DiD) framework, we find that green strategies significantly enhance corporate green revenues in the presence of China's Emission Trading Scheme (ETS) pilot. This is consistent with the Porter Hypothesis. Our mechanism analyses document that green strategies increase green revenues by improving green quality and catalyzing environmentally friendly transformation. This study has important implications for policymakers and practitioners, offering new insights into the intended consequences and real outcomes of environmental regulations.

1. Introduction

The intensely debated question is: can a firm's green strategies improve environmental performance while yielding green revenues? If such green revenues are attainable, what specific mechanisms facilitate their realization? This study examines the effects of green strategic responses to environmental regulation on firms' green revenues. The rapid development of emerging countries, including China, has fostered significant economic growth. However, this growth has coincided with increased air pollution (Huang et al., 2014) and adverse effects on public health (Vandyck et al., 2018). There is a strong tension between environmental integrity, social equity, and economic prosperity, constituting the three pillars of corporate sustainability (Bansal, 2005). On the one hand, neoclassical economic theory indicates that environmental regulations impose burdens on economic entities, diminishing their competitiveness and hindering innovation and productivity growth (Brunnermeier and Cohen, 2003). On the other hand, the Porter Hypothesis posits that stringent environmental regulations can stimulate innovation and enhance a firm's competitiveness, benefiting both the environment and the economy (Porter and van der Linde, 1995). Previous studies have examined that firm's green strategies can enhance their environmental performance (e.g., López et al., 2011; Wang et al., 2022). Yet, whether and how regulation-constrained firms' investment in green strategies affects green revenues remains a black box and requires rigorous empirical examination. Therefore, this study strives to answer this question and provides causal inferences through a quasi-natural experimental setting.

One worldwide regulation for mitigating climate change and lowering greenhouse gas (GHG) emissions is the Emission Trading Scheme (ETS). As of April 2022, the ETS have encompassed 34 jurisdictions worldwide, including China (World Bank, 2022). These operational ETSs cover 8.99 GtCO_2e, signifying the coverage of 17.55 % of global GHG emissions (World Bank, 2022). We focus on

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China's ETS pilot specifically, recognized as the world's largest ETS pilot, covering 1115 $MtCO_2e$. As China has undergone rapid economic growth since the 21st century, there has been a pronounced increase in its carbon emissions. PwC (2017) anticipates that China could become the largest country in terms of the projected GDP in purchasing power parties (PPPs) by 2050. However, data from the Climate Trade report[1] show that China became the world's largest carbon emitter, releasing 10,065 $MtCO_2e$ in 2021, comprising approximately 30 % of the global emissions. China, therefore, occupies a crucial position in the fight against global climate change. To achieve the net-zero emissions target in 2060, China's National Development and Reform Commission issued the *Notice on Pilot Carbon Emission Trading* in October 2011, mandating seven jurisdictions implementing the ETS pilot, named China's ETS pilot. Initiated in 2013, China's ETS pilot ultimately accomplished in 2014 (World Bank, 2014). The ETS worldwide and China's ETS pilot, however, are still in the infancy and have not yet covered all jurisdictions. It is urgent to provide ex-ante evidence of the effect on corporate revenues from the green industry to policymakers. These motivate us to focus on China's ETS pilot, given its generalizable and significant implications for operational ETSs and other environmental regulations in the world.

Previous literature finds that environmental regulations can increase corporate costs of pollution governance or debt (e.g., Brunnermeier and Cohen, 2003; Ni et al., 2022). However, more recent studies indicate that environmental regulations have positive effects on corporate environmental and financial performance, consistent with the Porter Hypothesis. For instance, Cao et al. (2023) find that China's low-carbon city pilot enhances the firm's human capital quality through increasing green innovation. Ren et al. (2022) show that China's ETS pilot enhances firms' environmental and financial performance by promoting green innovation. In addition, Liu and Li (2022) find that green innovation positively affects corporate green quality in the presence of China's ETS pilot. Hu et al. (2023) document that China's Environmental Protection Tax Law enhances corporate green transformation. Hence, we conjecture that green strategies increase corporate green revenues in the presence of China's ETS pilot by improving the green quality and catalyzing the environmentally friendly transformation.

We adopt a generalized Difference-in-Differences (DiD) framework to test our directional hypotheses. We find that corporate green strategies positively impact green revenues in the presence of China's ETS pilot. Our finding is consistent with the Porter Hypothesis. We further document that corporate green strategies enhance green revenues through enhancing green quality and catalyzing environmentally friendly transformation in the context of China's ETS pilot.

We also conduct a number of tests to deal with the potential endogeneity issues. First, we examine the parallel trend assumption using a dynamic analysis (Bertrand and Mullainathan, 2003) to check the validity of our DiD model. Second, we use the Entropy balancing approach (Hainmueller, 2012) to mitigate the sample-selection bias between treatment and control groups. Third, we employ placebo tests to establish fictitious environmental regulations and simulate 1000 times to ensure other related policies and confounding factors do not drive our results. Fourth, following Cao et al. (2023) and Pan et al. (2021), we conduct Oster's (2019) bound estimate to overcome the omitted variable bias.

Our study advances the literature and climate-change governance in three ways. First, our study sheds new light on the outcome of adopting green strategies, introducing a new concept denoted as green revenues. We address the hot-debated question of the three pillars of corporate sustainability (environmental integrity, social equity, and economic prosperity). We provide robust evidence that firms' investments in green strategies can increase their revenues from the green industry, thereby achieving a win-win situation between environmental and economic performance. Second, we enrich the emerging literature on the impacts of green strategies in the presence of environmental regulations. To our best, our study is the first to examine the impacts of green strategies on green revenues. Previous studies mainly focus on the relationship between green strategies and corporate governance (Amore and Bennedsen, 2016), green image (Chen, 2008), and compliance costs (Gray and Shadbegian, 2003). Furthermore, we uncover the internal mechanisms of green quality and environmentally friendly transformation. Third, we provide ex-ante evidence of the intended consequences of environmental regulation for policymakers and practitioners for further implementing ETS at a broad national or global level. This is because China's ETS pilot is still in the infancy stage and has yet to encompass all jurisdictions.

2. Theoretical mechanism and hypothesis development

Climate change is a prominent subject of contemporary socio-economic discourse. Governments worldwide are implementing diverse environmental regulations, including ETS, to mitigate GHG emissions in response to climate change challenges (Bartram et al., 2022). Gray (1987) documents that environmental regulations can raise a firm's costs and limit its ability to invest in research and development (R&D), creating a "compliance cost" effect. In contrast, the Porter Hypothesis suggests that strict environmental regulations can encourage innovation and boost a firm's competitiveness, resulting in advantages for both the environment and the economy (Porter and van der Linde, 1995). Studies such as Liu and Li (2022) show that China's ETS pilot positively affects corporate green innovation. Ren et al. (2022) also find that China's ETS pilot improves firms' environmental and financial performance by enhancing green innovation. Moreover, green innovation serves as a critical driving force for firms in realizing green strategies, thereby contributing to the sustainability of performance (Wang and Juo, 2021). Green innovation also emerges as a strategic firm resource, facilitating the establishment of a competitive advantage while concurrently contributing to sustainable development and addressing climate-change issues (Khanra et al., 2022). Therefore, corporate green strategies (i.e., green invention or utility-model investment) may improve their green revenues in China's ETS pilot context. We propose our first hypothesis accordingly as below:

H1. *Corporate green strategies enhance green revenues in the presence of China's ETS pilot.*

[1] Climate Trade report in 2021, available online at: https://climatetrade.com/which-countries-are-the-worlds-biggest-carbon-polluters/

Moreover, green technology effectively and efficiently addresses environmental issues and improves corporate environmental or green quality (Zhang, 2023). For instance, Liu and Li (2022) find that corporate green innovation can improve their green quality in the presence of China's ETS pilot. Therefore, firms' investment in green strategies enhances green revenues, likely because these strategies enhance their green quality in the presence of China's ETS pilot. Accordingly, we propose our second hypothesis as follows:

H2. *Corporate green strategies enhance green revenues through improving green quality in the presence of China's ETS pilot.*

Previous literature documents that firms' investment in environmental protection improves the corporate environment and green transformation in the presence of environmental regulations (see, e.g., Liu et al., 2022; Hu et al., 2023). Firms with greater environmentally friendly transformation are likely to focus more on green industries and reap the relevant benefits. Hence, we expect corporate green strategies to catalyze environmentally friendly transformation and enhance corporate green revenues, and we propose the third hypothesis as below:

H3. *Corporate green strategies enhance green revenues through catalyzing environmentally friendly transformation in the presence of China's ETS pilot.*

3. Sample, data and research design

3.1. Sample and data

We collect all China's A-share listed firms from 2009 to 2018, comprising four years before the first round of China's ETS pilot and four years after the last round of China's ETS pilot. We obtain information on firms' revenue from various business activities through the WIND database to classify corporate green revenues. We retrieve firms' financial data from the China Stock Market and Accounting Research Database (CSMAR). We delete specially treated (ST) and financial firms since they have different accounting fundamentals from other firms. We also drop firm-year observations with missing financial data. Eventually, our final sample contains 22,578 firm-year observations from 3329 unique firms. We winsorize all continuous variables at the 1st and 99th percentiles to ensure that outliers do not drive our results.

3.2. Research design

3.2.1. Model specification

The specification of our generalized DiD model with continuous variables (Angrist and Pischke, 2009) is as follows:

$$\text{GreenRevenue}_{\text{i,t}} = \alpha + \beta \text{GreenStrategies}_{\text{i,t}} \times \text{ETS}_{\text{i,t}} + \delta \text{X}_{\text{i,t}} + \varphi \nu_{\text{j}} + \varphi \upsilon_{\text{r}} + \psi \mu_{\text{t}} + \varepsilon_{\text{i,t}} \tag{1}$$

where the subscripts *i, t, r*, and *j* represent the firm, year, region, and industry, respectively. The outcome variable $GreenRevenue_{i,t}$ denotes corporate green revenues scaled by total revenues. The independent variables $GreenStrategies_{i,t}$ refers to corporate green strategies, measured by either green invention patent applications or green utility-model patent applications. $ETS_{i,t}$ equals one if a firm is headquartered in a jurisdiction subject to China's ETS pilot (treatment group), and zero otherwise (control group); $X_{i,t}$ is a vector of firm-specific control variables. In particular, we control for financial variables that likely affect green revenues, comprising corporate size (*Size*), listed age (*Age*), leverage ratio (*LEV*), net working capital (*NWC*), quick ratio (*QUICK*), market-to-book ratio (*MTB*), ROA (*ROA*), Tobin's Q (*TobinsQ*), tangible assets (*Tang*), and innovative subsidy (*Subsidy*). Industry, region, and year-fixed effects are also included in our model; and $\varepsilon_{i,t}$ is the error term. Robust standard errors are clustered at the industry level. Our main variable of interest is $GreenStrategies_{i,t}$, the coefficient β therefore captures the impacts of green strategies on green revenues in the presence of China's ETS pilot. The detailed variable definitions are provided in Appendix A.

3.2.2. Measures of green revenues

We identify corporate green revenues contingent upon the *2019 Green Industry Guiding Catalogue* (hereafter GIGC) issued by China's National Development and Reform Commission. The GIGC comprises six main categories of green business activities, encompassing 211 segmented activities. We categorize corporate revenues derived from business activities listed in the GIGC as "green revenues". We then measure corporate green revenues (*GR*) as aggregated green revenues scaled by total revenues.

3.2.3. Measures of green strategies

Patent applications provide detailed information on key features of the underlying invention, which are useful to classify innovations and technological strategy of firms (Amore and Bennedsen, 2016). Employing the number of innovation patent applications as a proxy for firms' green innovation is justified by the rationale that such applications serve as tangible indicators of firms' commitment to environmentally sustainable practices and the investment in eco-friendly technologies (Kim and Valentine, 2021; Li et al., 2023; Sunder et al., 2017). Therefore, following Kim and Valentine (2021) and Sunder et al. (2017), we use the number of green patent applications to measure the intensity of corporate green strategies. Specifically, green invention patent applications (*GI*) (Chen et al., 2021) and green utility-model patent applications (*GU*) (Quan et al., 2023) are used as proxies for corporate green strategies.

4. Empirical results

4.1. Descriptive statistics

Table 1 presents the summary statistics. The mean value of green revenues is 3.2 %, with a standard deviation of 0.142, indicating a significant variation in green revenues among firms. The mean value of *GI* (0.374) is close to that of *GU* (0.380), signifying that firms have the same investment preferences for green inventions and green utility models in our sample. The mean value of *ETS* (0.254) shows that 25.4 % of the sample is subject to China's ETS pilot.

4.2. Baseline results

Table 2 reports the results of the impacts of corporate green strategies on green revenues in the presence of China's ETS pilot. Columns (1)–(3) show that the coefficients on *GI*× *ETS* (0.040, 0.029, and 0.029) are all positive and also significant at the 1 % level. Columns (4)–(6) show that the coefficients on *GU*× *ETS* (0.057, 0.042, and 0.043) are all positive and significant at the 1 % level. Meanwhile, our results are economically significant. In the context of China's ETS pilot, the green invention (green utility model) increases corporate green revenues by approximately 16.96 % (25.15 %) of the standard deviation of the treatment group.[2] Considering the issue of reverse causality, we replace *GI*× *ETS* and *GU*× *ETS* with *L.GI*× *ETS* and *L.GU*× *ETS* (*GI* and *GU* with a one-year lag) to re-estimate our baseline model. Columns (7) and (8) show that our results remain robust. These results suggest that green inventions and utility models both raise corporate green revenues in the presence of China's ETS pilot, which supports our ***H1***. Our findings support the Porter Hypothesis (Porter and van der Linde, 1995), providing an intended consequences of attaining a win-win scenario between environmental regulation and financial performance. Previous studies (e.g., López et al., 2011; Wang et al., 2022) document that firms' green strategies can enhance their environmental performance. Our findings provide evidence that environmental sustainability (i.e., green strategies) significantly increase economic sustainability (i.e., corporate green revenues) based on the perspective of three pillars of corporate sustainability (Bansal, 2005).

4.3. Parallel trend tests

The parallel trend assumption stipulates that there should be a consistent trend in the coefficient before China's ETS pilot, with any divergence occurring only after the policy is implemented. We therefore perform a dynamic analysis by relacing *ETS* with nine indicator variables representing each year relative to China's ETS pilot.[3] Fig. 1 visualizes the results of parallel tend tests. We find that the effects of green strategies on green revenues are not significant prior to China's ETS pilot. However, corporate green revenues increase significantly after the implementation of China's ETS pilot. The *p*-value of joint significance F test in Panel A for prior to the China's ETS pilot equals 0.205 (F_A: $\sum_{-4}^{-1} ETSi = 0$), and for post to the China's ETS pilot equals 0.014 (F_A: $\sum_{0}^{+4} ETSi = 0$). That in Panel B for prior to the China's ETS pilot equals 0.155 (F_B: $\sum_{-4}^{-1} ETSi = 0$), and for post to the China's ETS pilot equals 0.001 (F_B: $\sum_{0}^{+4} ETSi = 0$). These results indicate that our tests are robust. Therefore, affected by China's ETS pilot, green strategies have positive effects on corporate green revenues.

4.4. Entropy balancing approach

To overcome the sample-selection bias, we follow Cao et al. (2023) to conduct an entropy-balancing approach to balance the treatment and control groups. This approach allows for achieving a covariate balance with fewer limitations and without the necessity of excluding any observations (Hainmueller, 2012). Panel A of Table 3 shows the differences in covariates before and after balancing. After balancing the differences between treatment and control groups, the covariates' standard deviation differences become zero, and the variance ratio equals one. It can be seen from Panel B of Table 3 that the coefficients on green strategies are all positive and significant at the 1% level, which suggests that our baseline results are robust after balancing treatment and control groups.

4.5. Placebo tests

In this section, we employ placebo tests to solve the potential endogeneity concern related to the effects of other policies or random factors on our results. Following Defusco (2018), we randomly allocate fictitious carbon emissions regulations to all jurisdictions and stimulate the placebo tests 1000 times. Fig. 2 illustrates that the pseudo-estimated coefficients are concentrated around zero. Meanwhile, the actual coefficients on green strategies are outliers and far from the distributions of the placebo coefficients. Hence, we conclude that other policies and random factors do not drive our baseline results.

[2] The coefficient on *GI*×*ETS* (0.029) / the standard deviation of *GR* for the treatment group (0.171); the coefficient on *GU*×*ETS* (0.043) / the standard deviation of *GR* for the treatment group (0.171).

[3] Four years (*ETS-4*), three years (*ETS-3*), two years (*ETS-2*), and one year (*ETS-1*) prior to China's ETS pilot and implementation year (*ETS0*), one year (*ETS+1*), two years (*ETS+2*), three years (*ETS+3*), and four years (*ETS+4*) after China's ETS pilot.

Table 1
Descriptive statistics.

Variable	N	Mean	SD	Min	P25	Median	P75	Max
GR	22,578	0.032	0.142	0.000	0.000	0.000	0.000	1.000
GI	22,578	0.374	0.772	0.000	0.000	0.000	0.693	4.060
GU	22,578	0.380	0.753	0.000	0.000	0.000	0.693	3.714
GPC	22,578	0.445	0.928	0.000	0.000	0.000	0.693	4.796
ET	19,516	0.874	0.865	0.000	0.000	0.693	1.386	3.332
ETS	22,578	0.254	0.435	0.000	0.000	0.000	1.000	1.000
Size	22,578	22.090	1.273	19.308	21.161	21.905	22.812	26.250
Age	22,578	2.785	0.361	1.099	2.565	2.833	3.045	3.526
LEV	22,578	0.436	0.206	0.078	0.267	0.426	0.592	0.908
NWC	22,578	0.218	0.251	−0.420	0.042	0.215	0.398	0.814
Quick	22,578	1.714	1.633	0.127	0.693	1.156	2.036	9.149
MTB	22,578	0.611	0.232	0.137	0.429	0.609	0.788	1.225
ROA	22,578	0.039	0.059	−0.551	0.015	0.038	0.067	0.201
TobinsQ	22,578	1.987	1.060	0.816	1.270	1.643	2.330	7.322
Tang	22,578	0.928	0.089	0.450	0.917	0.957	0.980	1.000
Subsidy	22,578	3.917	7.011	0.000	0.000	0.000	0.000	20.431

Note: This table presents the descriptive statistics of all variables. The variable definitions are shown in Appendix A.

Table 2
Impacts of green strategies on green revenues.

Variables	*Green revenues (GR)* (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GI× ETS	0.040***	0.029***	0.029***					
	(3.914)	(2.794)	(2.934)					
GU× ETS				0.057***	0.042***	0.043***		
				(4.396)	(3.348)	(3.552)		
L.GI× ETS							0.030***	
							(2.717)	
L.GU× ETS								0.043***
								(3.320)
Size		−0.003	−0.002		−0.003	−0.002	−0.002	−0.002
		(−0.874)	(−0.507)		(−0.967)	(−0.536)	(−0.666)	(−0.693)
Age		−0.024**	−0.025**		−0.024**	−0.025**	−0.028**	−0.029**
		(−2.059)	(−2.148)		(−2.106)	(−2.195)	(−2.063)	(−2.115)
LEV		0.045**	0.042**		0.046**	0.043**	0.048**	0.049**
		(2.373)	(2.280)		(2.392)	(2.291)	(2.356)	(2.379)
NWC		0.027	0.028		0.027	0.029	0.028	0.029
		(1.283)	(1.330)		(1.319)	(1.396)	(1.216)	(1.256)
QUICK		−0.002	−0.002*		−0.002	−0.002	−0.002	−0.001
		(−1.574)	(−1.672)		(−1.287)	(−1.355)	(−1.168)	(−0.840)
MTB		−0.031***	−0.034***		−0.032***	−0.035***	−0.034***	−0.035***
		(−2.958)	(−2.856)		(−3.115)	(−3.024)	(−2.968)	(−3.078)
ROA		−0.006	−0.009		−0.009	−0.011	−0.000	−0.003
		(−0.223)	(−0.290)		(−0.299)	(−0.369)	(−0.002)	(−0.095)
TobinsQ		−0.007***	−0.007***		−0.007***	−0.007***	−0.008***	−0.008***
		(−2.793)	(−2.930)		(−2.796)	(−2.918)	(−2.797)	(−2.818)
Tang		−0.021	−0.019		−0.022	−0.020	−0.024	−0.025
		(−0.721)	(−0.645)		(−0.782)	(−0.730)	(−0.792)	(−0.888)
Subsidy		0.001***	0.001***		0.001***	0.001***	0.001**	0.001**
		(3.104)	(3.055)		(2.999)	(2.960)	(2.523)	(2.287)
Constant	0.026***	0.186**	0.162**	0.025***	0.188***	0.163**	0.195**	0.195**
	(3.944)	(2.542)	(2.273)	(4.139)	(2.649)	(2.334)	(2.370)	(2.410)
Industry FE	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Region FE	No	No	Yes	No	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Obs.	22,578	22,577	22,577	22,578	22,577	22,577	18,522	18,522
Adj. R^2	0.021	0.150	0.154	0.038	0.158	0.162	0.165	0.172

Note: This table presents the impacts of corporate green strategies on green revenues in the presence of China's ETS pilot. Columns (1) to (3) show the results of the impacts of green inventions on green revenues. Columns (4) to (6) show the results of the impacts of the green utility model on green revenues. Columns (7) and (8) report the results of the impacts of the green strategies with a one-year lag on green revenues. These results indicate that corporate green invention and utility model both enhance green revenues in the presence of China's ETS pilot. The variable definitions are shown in Appendix A. The *t*-statistics are reported in parentheses. Robust standard errors are clustered by industry. *, **, and *** denote statistical significance at 10 %, 5 %, and 1 % levels, respectively.

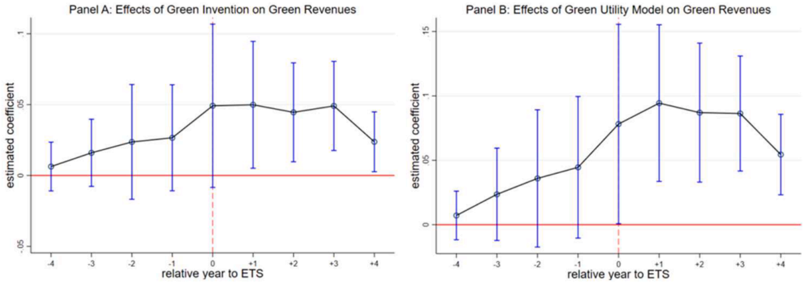

Fig. 1. Parallel trend tests

Table 3
Results of the entropy balancing approach.

Panel A. Entropy balancing approach results									
Before balancing	Treatment group (N = 5740)			Control group (N = 16,838)			Std.	Var.
	Mean	Variance	Skewness	Mean	Variance	Skewness	Diff.	Ratio
Size	22.310	1.968	0.827	22.020	1.481	0.665	0.186	1.329
Age	2.876	0.110	−0.618	2.754	0.133	−1.150	−0.032	0.831
LEV	0.424	0.041	0.259	0.440	0.043	0.182	−0.005	0.956
NWC	0.251	0.055	−0.122	0.207	0.066	0.000	−0.022	0.838
QUICK	1.838	2.655	1.978	1.672	2.666	2.217	−0.003	0.996
MTB	0.589	0.058	0.245	0.619	0.053	0.014	0.010	1.093
ROA	0.040	0.004	−3.635	0.039	0.003	−2.246	0.005	1.179
TobinsQ	2.097	1.285	1.779	1.950	1.063	2.005	0.102	1.209
Tang	0.916	0.011	−2.134	0.932	0.007	−2.747	0.021	1.576
Subsidy	5.954	63.540	0.624	3.223	42.350	1.553	1.463	1.500
After balancing	Treatment group (N = 5740)			Control group (N = 16,838)			Std.	Var.
	Mean	Variance	Skewness	Mean	Variance	Skewness	Diff.	Ratio
Size	22.310	1.968	0.827	22.310	1.968	0.827	0.000	1.000
Age	2.876	0.110	−0.618	2.876	0.111	−0.619	0.000	1.000
LEV	0.424	0.041	0.259	0.424	0.041	0.259	0.000	1.000
NWC	0.251	0.055	−0.122	0.251	0.055	−0.122	0.000	1.000
QUICK	1.838	2.655	1.978	1.838	2.655	1.978	0.000	1.000
MTB	0.589	0.058	0.245	0.589	0.058	0.245	0.000	1.000
ROA	0.040	0.004	−3.635	0.040	0.004	−3.635	0.000	1.000
TobinsQ	2.097	1.285	1.779	2.097	1.285	1.779	0.000	1.000
Tang	0.916	0.011	−2.134	0.916	0.011	−2.134	0.000	1.000
Subsidy	5.954	63.540	0.624	5.954	63.530	0.624	0.000	1.000

Panel B. Effects of green strategies on green revenues after balancing						
Variables	*Green Revenues* (*GR*)					
	(1)	(2)	(3)	(4)	(5)	(6)
GI× *ETS*	0.040***	0.030***	0.032***			
	(3.906)	(2.844)	(2.998)			
GU× *ETS*				0.058***	0.044***	0.047***
				(4.355)	(3.326)	(3.478)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	No	Yes	Yes
Region FE	No	No	Yes	No	No	Yes
Year FE	No	Yes	Yes	No	Yes	Yes
Obs.	22,578	22,577	22,577	22,578	22,577	22,577
Adj. R^2	0.034	0.165	0.170	0.062	0.178	0.184

Note: This table shows the impacts of green strategies on green revenues after conducting the Entropy balancing approach to ensure our results are not driven by sample-selection bias. Panel A shows the results of the entropy balancing approach and the differences between before and after balancing treatment and control groups. Panel B exhibits the results of the impacts of green strategies on green revenues after balancing treatment and control groups. These results indicate that our baseline results are robust and not driven by sample selection bias. The variable definitions are shown in Appendix A. The *t*-statistics are reported in parentheses. Robust standard errors are clustered by industry. *, **, and *** denote statistical significance at 10 %, 5 %, and 1 % levels, respectively.

4.6. Omitted variable bias tests

To deal with the omitted variable bias, following Cao et al. (2023) and Pan et al. (2021), we adopt Oster's (2019) bound estimate to assess coefficient estimate sensitivity and changes in R-squared between regressions with and without control variables for

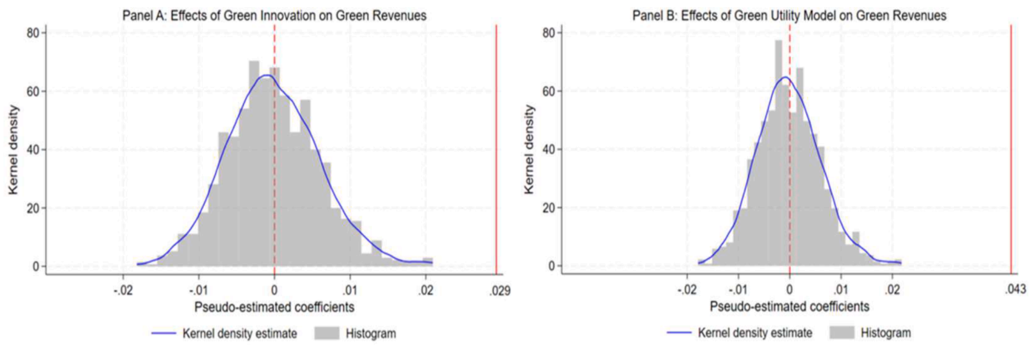

Fig. 2. Placebo tests.

comparison. We use two parameters: selection proportionality (δ) and R_{max} that represents the maximum R-squared for regressions when omitted variables are included in the analysis. We then conduct two omitted variable bias tests to examine the robustness of our results following Oster (2019). First, we let δ equals one, and R_{max} equals 1.3 times the adjusted R-squared. Therefore, our results are unlikely to be driven by omitted variable bias when β* (i.e., β* =β*(R_{max},δ)) is within the 95 % confidence interval of our treatment variables. Second, we let β* equals zero and R_{max} equals 1.3 times the adjusted R-squared. Hence, omitted variable bias is unlikely to appear if δ is larger than 1 or less than −1. Table 4 shows that β* for the effects of *GI* × *ETS* (0.024) and *GP* × *ETS* (0.036) on green revenues are both within the 95 % confidence interval. In addition, δ for the effects of *GI* × *ETS* (3.487) and *GP* × *ETS* (3.202) on green revenues are both larger than 1. These indicate that our baseline results are robust and not driven by the omitted variable bias.

5. Mechanism analysis

5.1. Green quality channel

This section examines whether corporate green strategies improve green revenues in the presence of China's ETS pilot by increasing green quality. We use green patent citations (*GPC*) to proxy corporate green quality following Sunder et al. (2017). We define the indicator variable *HighGPC* (*LowGPC*) that equals one when *GPC* is above (below) the median value, and zero otherwise.

Panel A of Table 5 presents the results of the green quality channel. Columns (1) and (2) show that the coefficients on *GI* × *ETS* (0.458) and *GU* × *ETS* (0.436) are both significantly positive at the 1 % level, implying that green inventions and utility models have positive effects on green quality. In Columns (3) and (4), we find that the coefficients on *GI* × *ETS* × *HighGPC* (0.035) and *GU* × *ETS* × *HighGPC* (0.051) are significantly larger than that on *GI* × *ETS* × *LowGPC* (0.015) and *GU* × *ETS* × *LowGPC* (0.021). This suggests that green strategies raise corporate green revenues through improving green quality in the presence of China's ETS pilot, which supports our ***H2***. Zhang (2023) documents that firms' green technology improves corporate environmental and green quality. Liu and Li (2022) find that firms' green innovation can improve their green quality in the presence of China's ETS pilot. Our findings shed light that, in the presence of China's ETS pilot, green strategies contribute to an increase in green quality, thereby enhancing corporate green revenues.

Table 4
Omitted variable bias tests.

Panel A. Effects of green invention on green revenues		
Standard	(1) Estimated value	(2) Omitted variables bias
β*(R_{max},δ)ε[0.009, 0.049]	β*(R_{max},δ) = 0.024	Unlikely
δ> 1orδ< -1	δ= 3.487	Unlikely
Panel B. Effects of green utility model on green revenues		
Standard	(1) Estimated value	(2) Omitted variables bias
β*(R_{max},δ)ε[0.019, 0.067]	β*(R_{max},δ) = 0.036	Unlikely
δ> 1orδ< -1	δ= 3.202	Unlikely

Note: This table reports the omitted variable bias test results using Oster's (2019) bound estimate. We assess the sensitivity of estimated coefficients and the change in R-squared between regression models with and without control variables. To test for potential omitted variable bias, we employ the selection proportionality parameter δ and maximum goodness-of-fit R_{max}. We use the model proposed by Oster (2019), denoted as β* =β*(R_{max},δ), which yields consistent estimates of the actual coefficients. Our findings demonstrate that omitted variable bias does not impact our results.

Table 5
Mechanism analysis.

Panel A. Green quality channel				
Variables	*Green Patent Citation* (*GPC*)		*Green Revenues* (*GR*)	
	(1)	(2)	(3)	(4)
GI× *ETS*	0.458***			
	(23.040)			
GU× *ETS*		0.436***		
		(21.904)		
GI × *ETS* × *HighGPC* (β1)			0.035***	
			(7.940)	
GI × *ETS* × *LowGPC* (β2)			0.015**	
			(2.430)	
GU × *ETS* × *HighGPC* (β1)				0.051***
				(9.803)
GU × *ETS* × *LowGPC* (β2)				0.021***
				(3.110)
Control	Yes	Yes	Yes	Yes
Industry + Region + Year FE	Yes	Yes	Yes	Yes
F: β1- β2 (*p*-value)			0.009***	0.000***
Obs.	22,577	22,577	22,577	22,577
Adj. R^2	0.287	0.276	0.276	0.164

Panel B. Environmentally friendly transformation channel				
Variables	*Environmental awareness* (*ET*)		*Green Revenues* (*GR*)	
	(1)	(2)	(3)	(4)
GI× *ETS*	0.029**			
	(2.210)			
GU× *ETS*		0.089***		
		(6.486)		
GI × *ETS* × *HighET* (β1)			0.049***	
			(8.002)	
GI × *ETS* × *LowET* (β2)			0.011**	
			(2.412)	
GU × *ETS* × *HighET* (β1)				0.056***
				(9.122)
GU × *ETS* × *LowET* (β2)				0.031***
				(4.527)
Control	Yes	Yes	Yes	Yes
Industry + Region + Year FE	Yes	Yes	Yes	Yes
F: β1- β2 (*p*-value)			0.000***	0.005***
Obs.	19,515	19,515	19,515	19,515
Adj. R^2	0.255	0.257	0.164	0.170

Note: This table shows the results of the mechanism analyses. Panel A reports the channel of green quality. *HighGPC* (*LowGPC*) equals one when *GPC* is above (below) the median value, and zero otherwise. It shows that green strategies enhance green revenues through improving green quality. Panel B reports the channel of environmentally friendly transformation. *HighET* (*LowET*) equals one when *ET* is above (below) the median value, and zero otherwise. It shows that green strategies enhance green revenues through catalyzing environmentally friendly transformation. The variable definitions are shown in Appendix A. The *t*-statistics are reported in parentheses. Robust standard errors are clustered by industry. *, **, and *** denote statistical significance at 10 %, 5 %, and 1 % levels, respectively.

5.2. Environmentally friendly transformation channel

We also examine investments in green strategies to enhance corporate green revenues in the presence of China's ETS pilot through catalyzing environmentally friendly transformation. We employ the textual analysis method to measure corporate digital transformation, which is further used as the proxy for environmentally friendly transformation (*ET*) (e.g., Cui et al., 2023; Du et al., 2023). Specifically, we use Python to extract the frequency of words related to environmentally friendly transformation from firms' annual and corporate social responsibility (CSR) reports. We define the indicator variable *HighET* (*LowET*) that equals one when *ET* is above (below) the median value, and zero otherwise.

Panel B of Table 5 reports the results of the environmentally friendly transformation channel. Columns (1) and (2) show that the coefficients on *GI* × *ETS* (0.029) and *GU* × *ETS* (0.089) are both positive and significant at the 1 % level, which indicates that green inventions and utility models have positive impacts on firms' environmentally friendly transformation. Moreover, it can be seen from columns (3) and (4) that the coefficients on *GI* × *ETS* × *HighET* (0.049) and *GU* × *ETS* × *HighET* (0.056) are significantly larger than that on *GI* × *ETS* × *LowET* (0.011) and *GU* × *ETS* × *LowET* (0.031). This implies that green strategies enhance green revenues through catalyzing environmentally friendly transformation in the presence of China's ETS pilot, which supports our ***H3***. The existing literature documents that firms' investments in environmental protection lead to improvements in the firms' environmental performance and facilitate green transformation, particularly in the context of environmental regulations (e.g., Hu et al., 2023; Liu et al., 2022). Our findings provide evidence that green strategies catalyze environmentally friendly transformation, thereby enhancing corporate green revenues.

6. Conclusion

This paper examines a hotly debated issue of strong tension between environmental protection and firms' financial performance. We find that corporate green strategies have positive effects on firms' green revenues in the presence of China's ETS pilot. Our mechanism analyses show that green strategies raise green revenues by enhancing green quality and accelerating environmentally friendly transformation. Our findings have important implications for environmental regulations on the intended consequences (e.g., increased corporate green revenues). Considering ETSs worldwide and China's ETS pilot are still in the infancy stage and have not yet covered all jurisdictions. Therefore, we provide ex-ante evidence on promoting the effectiveness of corporate green strategies in the framework of environmental regulations to policymakers and practitioners for further development. This study has important implications for international and local investors. Our findings provide crucial guidance to aid them in making more informed decisions regarding the sustainability.

CRediT authorship contribution statement

Zijie Huang: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **June Cao:** Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. **Lei Pan:** Conceptualization, Investigation, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

Data availability

The authors do not have permission to share data.

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Appendix A. Definition of variables

Variable	Definition
Dependent and treatment variables	
GR	Corporate green revenues scaled by total revenues
GI	Logarithmic value of the number of green invention patent application
GU	Logarithmic value of the number of green utility-model patent application
ETS	The dummy variable equals one if the firm is headquartered in a jurisdiction subject to China's ETS pilot (treatment group), and zero otherwise (control group)
GPC	Logarithmic value of the number of citations of green patents
ET	Logarithmic value of the frequency of words related to environmentally friendly transformation in firms' annual and CSR report
Control variables	
Size	Logarithm of total assets
Age	Logarithmic value of firms' age
LEV	Debt-to-Asset ratio
NWC	Net working capital scaled by total assets
QUICK	The sum of cash, short-term investments, and receivables scaled by current liabilities
MTB	Markert-to-book ratio
ROA	Logarithmic value of return on assets
TobinsQ	Tobin's Q value of firm
Tang	Total tangible assets scaled by total assets
Subsidy	Logarithmic value of innovation subsidy

References

Amore, M.D., Bennedsen, M., 2016. Corporate governance and green innovation. J. Environ. Econ. Manag. 75, 54–72.
Angrist, J.D., Pischke, J.S., 2009. Mostly Harmless Econometrics: An Empiricist's Companion. Princeton University Press.
Bansal, P., 2005. Evolving sustainably: a longitudinal study of corporate sustainable development. Strateg. Manag. J. 26 (3), 197–218.
Bartram, S.M., Hou, K., Kim, S., 2022. Real effects of climate policy: financial constraints and spillovers. J. Financ. Econ. 143 (2), 668–696.

Bertrand, M., Mullainathan, S., 2003. Enjoying the quiet life? Corporate governance and managerial preferences. J. Polit. Econ. 111 (5), 1043–1075.
Brunnermeier, S.B., Cohen, M.A., 2003. Determinants of environmental innovation in US manufacturing industries. J. Environ. Econ. Manag. 45 (2), 278–293.
Cao, J., Li, W., Hasan, I., 2023. The impact of lowering carbon emissions on corporate labour investment: a quasi-natural experiment. Energy Econ. 121, 106653.
Chen, Y.S., 2008. The driver of green innovation and green image - Green core competence. J. Bus. Ethics 81 (3), 531–543.
Chen, Z., Zhang, J., Zi, Y., 2021. A cost-benefit analysis of R&D and patents: firm-level evidence from China. Eur. Econ. Rev. 133, 103633.
Cui, H., Zhou, X., Luo, Y., 2023. Digital transformation and bond credit spread. Financ. Res. Lett. 58, 104553.
Defusco, A.A., 2018. Homeowner borrowing and housing collateral: new evidence from expiring price controls. J. Financ. 73 (2), 523–573.
Du, J., Shen, Z., Song, M., Zhang, L., 2023. Nexus between digital transformation and energy technology innovation: an empirical test of A-share listed enterprises. Energy Econ. 120, 106572.
Gray, W.B., 1987. The cost of regulation: OSHA, EPA and the productivity slowdown. Am. Econ. Rev. 77 (5), 998–1006.
Gray, W.B., Shadbegian, R.J., 2003. Plant vintage, technology, and environmental regulation. J. Environ. Econ. Manag. 46 (3), 384–402.
Hainmueller, J., 2012. Entropy balancing for causal effects: a multivariate reweighting method to produce balanced samples in observational studies. Polit. Anal. 20 (1), 25–46.
Hu, J., Fang, Q., Wu, H., 2023. Environmental tax and highly polluting firms' green transformation: evidence from green mergers and acquisitions. Energy Econ. 127, 107046.
Huang, R.J., et al., 2014. High secondary aerosol contribution to particulate pollution during haze events in China. Nature 514 (7521), 218–222.
Khanra, S., Kaur, P., Joseph, R.P., Malik, A., Dhir, A., 2022. A resource-based view of green innovation as a strategic firm resource: present status and future directions. Bus. Strategy Environ. 31 (4), 1395–1413.
Kim, J., Valentine, K., 2021. The innovation consequences of mandatory patent disclosures. J. Account. Econ. 71 (2–3), 101381.
Li, C., Xu, R., Zhou, Y., 2023. Star academicians: gimmicks or game-changers? J. Corp. Financ. 82, 102452.
Liu, G., et al., 2022. Environmental tax reform and environmental investment: a quasi-natural experiment based on China's environmental protection tax law. Energy Econ. 109, 106000.
Liu, M., Li, Y., 2022. Environmental regulation and green innovation: evidence from China's carbon emissions trading policy. Financ. Res. Lett. 48, 103051.
López, R., Galinato, G.I., Islam, A., 2011. Fiscal spending and the environment: theory and empirics. J. Environ. Econ. Manag. 62 (2), 180–198.
Ni, X., Jin, Q., Huang, K., 2022. Environmental regulation and the cost of debt: evidence from the carbon emission trading system pilot in China. Financ. Res. Lett. 49, 103134.
Oster, E., 2019. Unobservable selection and coefficient stability: theory and evidence. J. Bus. Econ. Stat. 37 (2), 187–204.
Pan, L., Biru, A., Lettu, S., 2021. Energy poverty and public health: global evidence. Energy Econ. 101, 105423.
Porter, M.E., van der Linde, C., 1995. Toward a new conception of the environment-competitiveness relationship. J. Econ. Perspect. 9 (4), 97–118.
PwC, 2017. The Long View: How will the Global Economic order Change by 2050? PwC analysis.
Quan, X., Ke, Y., Qian, Y., Zhang, Y., 2023. CEO foreign experience and green innovation: evidence from China. J. Bus. Ethics 182 (2), 535–557.
Ren, S., Yang, X., Hu, Y., Chevallier, J., 2022. Emission trading, induced innovation and firm performance. Energy Econ. 112, 106157.
Sunder, J., Sunder, S.V., Zhang, J., 2017. Pilot CEOs and corporate innovation. J. Financ. Econ. 123 (1), 209–224.
Vandyck, T., et al., 2018. Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris agreement pledges. Nat. Commun. 9 (1), 1–11.
Wang, C.H., Juo, W.-J., 2021. An environmental policy of green intellectual capital: green innovation strategy for performance sustainability. Bus. Strategy. Environ. 30 (7), 3241–3254.
Wang, Q.J., Wang, H.J., Chang, C.P., 2022. Environmental performance, green finance and green innovation: what's the long-run relationships among variables? Energy Econ. 110, 106004.
World Bank, 2014. State and Trends of Carbon Pricing 2014. World Bank Publication.
World Bank, 2022. State and Trends of Carbon Pricing 2022. World Bank Publication.
Zhang, D., 2023. Can environmental monitoring power transition curb corporate greenwashing behavior? J. Econ. Behav. Org. 212, 199–218.