ISSN 2616-5902 Vol. 8, Issue 4: 61-66, DOI: 10.25236/AJBM.2026.080408

The Crowding-out Effect of Environmental Taxation on Green Innovation and Ownership Heterogeneity: DID Evidence from China's 2018 Environmental Protection Tax Law

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Abstract: *Exploiting China's 2018 Environmental Protection Tax Law as an exogenous shock, this paper applies a difference-in-differences (DID) model to 28,331 firm-year observations from listed manufacturing enterprises (2012–2024). We find that the environmental tax exerts an overall suppressive effect on green innovation. However, this reduction is entirely driven by a drop in low-quality green utility models, leaving high-quality green invention patents unaffected. Crucially, this crowding-out effect is strictly concentrated within state-owned enterprises (SOEs), where rigid political compliance forces a diversion of R&D funds toward short-term end-of-pipe treatments. In contrast, private firms successfully absorb the regulatory shock through market-oriented flexibility and operational optimization. Our results demonstrate that the Porter Hypothesis is deeply contingent upon corporate ownership structure, suggesting that policymakers must complement environmental taxation with targeted fiscal incentives to mitigate R&D crowding-out effects in SOEs.*

Keywords: *Green innovation; Environmental Protection Tax Law; Manufacturing firms; Ownership heterogeneity; Difference-in-differences (DID)*

1. Introduction

Facilitating the green transformation of the manufacturing sector is critical to realizing China's "dual carbon" objectives. In 2018, the implementation of the *Environmental Protection Tax Law* catalyzed a shift from administrative emission fees to a market-based taxation regime. Despite its overarching goals, the efficacy of this policy is profoundly contingent upon micro-level corporate behaviors, which vary significantly across distinct ownership structures. Constrained by rigid political mandates and local performance metrics, state-owned enterprises (SOEs) frequently resort to short-term, end-of-pipe compliance measures, thereby crowding out critical R&D funds. Conversely, private enterprises leverage market-oriented agility to absorb compliance costs through process optimization, thereby sustaining their innovation momentum. To unpack this dynamic, this paper utilizes a difference-in-differences (DID) framework to evaluate the causal impact of the environmental tax on green innovation. By delineating the asymmetric responses between SOEs and private firms, this study offers insights for designing more precise environmental policy mixes and fostering effective corporate green strategies.

2. Literature Review

The nexus between environmental regulation and corporate innovation is traditionally explained by two prominent theoretical frameworks: the "Porter Hypothesis" and the "crowding-out effect." Porter and van der Linde (1995) initially posited that appropriate regulation could stimulate innovation through a compensatory effect[1]. Jaffe and Palmer (1997) provided empirical support, finding a positive correlation between regulatory stringency and R&D expenditure[2]. Acemoglu et al. (2012) further substantiated this from the perspective of directed technological change, arguing that carbon taxes can incentivize the development of clean innovations[3]. Conversely, Ambec and Barla (2002) contended that under financing constraints, regulation might crowd out R&D investment[4]. Within the Chinese institutional context, Ren et al. (2021) highlighted the crucial moderating role of property rights, suggesting that state-owned enterprises tend toward end-of-pipe solutions, whereas private enterprises exhibit greater market

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flexibility[5]. Earlier, Lanjouw and Mody (1996) addressed the heterogeneity of patent quality, laying a methodological foundation for classifying green patents[6]. Harrison et al. (2013) underscored corporate heterogeneity as central to understanding variations in policy effectiveness[7]. In summary, existing research has largely focused on average effects across entire samples, neglecting the differentiated mechanisms under the interplay of property rights and tax system reforms.

3. Theoretical Analysis and Research Hypotheses

3.1 The "Crowding-Out Effect" of Environmental Taxes on Green Innovation

Following the introduction of environmental taxes, enterprises face increased financial pressure, forcing a trade-off in resource allocation. While green innovation requires substantial, long-term investment, end-of-pipe treatment provides a cost-effective and rapid way to achieve compliance and avoid penalties. Faced with these alternatives, managers often favor short-term end-of-pipe solutions, leading to a "crowding-out effect" on green R&D. We therefore propose:

H1: The Environmental Protection Tax Law crowds out green innovation within manufacturing enterprises.

3.2 Property Heterogeneity and Divergent Micro-Policy Responses

State-owned enterprises (SOEs) are likely to experience a more severe crowding-out effect. Their unique institutional environment subjects them to heavier political mandates and administrative pressure regarding environmental targets. Combined with performance appraisals that reward short-term compliance, SOE managers are incentivized to choose low-risk end-of-pipe governance over long-term innovation. Consequently, we propose:

H2: The crowding-out effect of the Environmental Protection Tax Law is more pronounced in SOEs than in private firms.

Conversely, private enterprises possess greater strategic flexibility. With less administrative pressure to meet immediate political targets, they can avoid over-investing in end-of-pipe facilities and maintain their commitment to R&D. Furthermore, private firms often mitigate tax burdens through flexible input reallocation and process optimization. This resilience helps them sustain innovation despite rising tax costs. Thus, we propose:

H3: The Environmental Protection Tax Law has no significant crowding-out effect on green innovation in private enterprises.

4. Research Design

4.1 Sample Selection and Data Sources

Our study examines A-share listed manufacturing enterprises in China from 2012 to 2024—a period that captures the 2018 implementation of the Environmental Protection Tax Law. Primary data on green innovation and financial performance were sourced from the CNRDS and CSMAR databases. We applied the following screening procedures to ensure the reliability of the empirical results: first, firms under "Special Treatment" (ST and *ST) were removed; second, firms with incomplete data for key variables were excluded; and third, any firms experiencing significant asset restructuring or shifts in their core business categories were omitted to maintain consistency. Additionally, all continuous variables were winsorized at the 1st and 99th percentiles to minimize the influence of extreme values. This process resulted in a final sample of 28,331 firm-year observations.

4.2 Variable Definition

4.2.1 Explained Variable: Corporate Green Innovation

This study uses the level of corporate green innovation as the dependent variable, measured by a firm's annual green patent applications. Because patent count data is typically right-skewed and frequently contains zero values, we measure green innovation output by taking the natural logarithm of the patent count plus one. Based on this approach, three specific indicators are constructed: total green

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patent applications (*ln_Green_Total*), green invention patents (*ln_Green_Inv*), and green utility model patents (*ln_Green_UM*).

4.2.2 Key Explanatory Variable: Environmental Tax Policy Shock (DID)

The core explanatory variable is the difference-in-differences (DID) interaction term *Treat* × *Period*, based on the 2018 *Environmental Protection Tax Law*. *Period* is an indicator variable set to 1 for 2018 and subsequent years, and 0 otherwise. Because the law allowed local authorities to adjust tax rates, some provinces (e.g., Beijing, Tianjin, and Hebei) substantially increased the tax burden compared to the historical pollutant discharge fees, while others (e.g., Liaoning, Jilin, and Anhui) merely converted the existing fees into taxes without rate hikes. Accordingly, firms registered in provinces with increased tax rates constitute the treatment group (*Treat* = 1), whereas those in provinces maintaining the previous standards serve as the control group (*Treat* = 0).

4.2.3 Control Variables

To minimize omitted variable bias and isolate the net effect on green innovation, we incorporate an extensive set of control variables. These comprehensive firm-level controls comprise firm size, leverage, profitability, cash flow adequacy, fixed asset ratio, firm growth, ownership concentration, firm age, ownership type, and heavy pollution status.

4.3 Model Specification

To empirically examine the impact of the 2018 *Environmental Protection Tax Law* on corporate green innovation, this study leverages the policy's implementation as a quasi-natural experiment. Following established practices in environmental policy evaluation, we specify the following two-way fixed effects (TWFE) panel regression model:

$$Green_{i,t} = \alpha_0 + \alpha_1 DID_{i,t} + \sum \beta_k Controls_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

Where subscripts i and t denote firm and year, respectively. $Green_{i,t}$ represents firm i's green innovation output in year t, and $DID_{i,t}$ is the interaction term for the environmental tax reform. $Controls_{i,t}$ includes a set of firm-specific control variables affecting green innovation. The terms μ_i and δ_t denote firm and year fixed effects, respectively, which control for unobservable, time-invariant firm traits and time-varying macroeconomic shocks. $\varepsilon_{i,t}$ is the random error term. To ensure robust statistical inference by accounting for potential serial correlation within firms, standard errors are clustered at the firm level. This rigorous difference-in-differences specification effectively addresses major endogeneity concerns.

4.4 Descriptive Statistics

Table 1: Descriptive Statistics

VarName	Obs	Mean	SD	Min	Median	Max
Pollute	28331	0.270	0.444	0.000	0.000	1.000
SOE	28331	0.248	0.432	0.000	0.000	1.000
Size	28331	22.103	1.172	19.876	21.941	25.657
Lev	28331	0.396	0.194	0.052	0.387	0.887
ROA	28331	0.033	0.066	-0.245	0.035	0.200
CashFlow	28331	0.049	0.066	-0.149	0.047	0.238
Fixed	28331	0.222	0.132	0.013	0.199	0.608
Growth	28331	0.129	0.331	-0.523	0.084	1.833
Top1	28331	0.325	0.140	0.086	0.303	0.715
ln_Green_Total	28331	0.927	1.191	0.000	0.693	4.812
ln_Green_Inv	28331	0.629	0.999	0.000	0.000	4.357
ln_Green_UM	28331	0.608	0.924	0.000	0.000	3.784
lnAge	28331	2.983	0.303	2.079	2.996	3.611
DID	28331	0.278	0.448	0.000	0.000	1.000

Table 1 presents the summary statistics for the main variables. Following the removal of missing values and data winsorization, the final sample yields 28,331 firm-year observations. The natural logarithm of total green patents (*ln_Green_Total*) averages 0.927 with a standard deviation of 1.191. The

ISSN 2616-5902 Vol. 8, Issue 4: 61-66, DOI: 10.25236/AJBM.2026.080408

lower mean of green invention patents (*ln_Green_Inv* = 0.629) indicates considerable heterogeneity in corporate green innovation, reflecting a shortage of high-quality, complex green technologies among Chinese listed firms. The core interaction term, *DID*, has a mean of 0.278. For key controls, the average leverage (*Lev*) is 0.396, top shareholder ownership (*Top1*) is 0.325, and state-owned enterprises (*SOE*) represent 24.8% of the observations. The distributions of all variables are consistent with prior literature, demonstrating the validity and representativeness of the sample.

5. Empirical Analysis

5.1 Parallel Trends Assumption

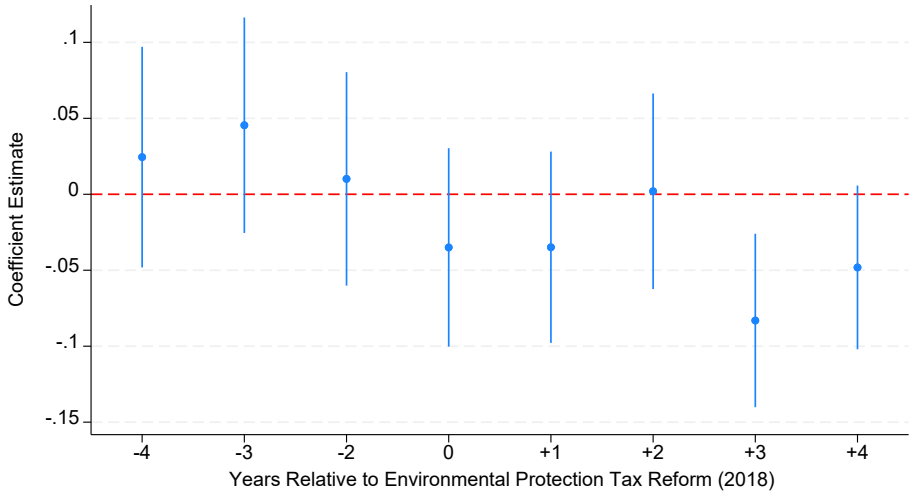

Figure 1: Plot of Parallel Trends

Figure 1 illustrates the results of the parallel trends test, a crucial prerequisite for the validity of our DID model. The coefficients for all pre-policy periods (periods -4 to -2) are statistically insignificant, confirming that no systematic differences existed between the treatment and control groups prior to the tax reform. Additionally, the dynamic estimates indicate a lagged policy response. While the coefficients for the implementation year and the explicit short-term window (periods 0 to +2) remain negative but non-significant, a significantly negative impact emerges at the 5% level in year +3. This evidence suggests a transmission lag in the crowding-out effect: the increased short-term environmental compliance costs culminate in a significant reduction in green innovation output by the third year.

5.2 Baseline Regression Results

Table 2: Baseline Regression Results

	(1)	(2)	(3)
VARIABLES	ln_Green_Total	ln_Green_Inv	ln_Green_UM
DID	-0.0770**	-0.0348	-0.0589**
	(0.0333)	(0.0296)	(0.0281)
Size	0.414***	0.337***	0.284***
	(0.0237)	(0.0227)	(0.0198)
Observations	28,052	28,052	28,052
R-squared	0.770	0.758	0.702
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Controls	YES	YES	YES

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 2 presents the baseline two-way fixed effects DID estimates regarding the environmental tax's effect on corporate green innovation. In Column (1), the main explanatory variable, *DID*, yields a coefficient of -0.0770, which is significantly negative at the 5% level. This implies a significant post-reform decline in overall green innovation for treated firms compared to their control counterparts, thus

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validating Hypothesis 1 (H1).

When analyzing specific innovation types, the results indicate an asymmetric policy impact. The tax reform significantly inhibited green utility model patents (Column 3, coefficient = -0.0589, $p < 0.05$), which are characterized by lower innovation thresholds and incremental features. In contrast, the policy's effect on more substantive green invention patents (Column 2) is negative (-0.0348) but statistically insignificant. Additionally, the estimates for the control variables largely align with prior theoretical expectations.

5.3 Heterogeneity in Ownership Structure

Table 3: Heterogeneity Analysis

	(1)	(2)
VARIABLES	SOEs	Private
DID	-0.155**	-0.0390
	(0.0689)	(0.0377)
Size	0.437***	0.415***
	(0.0450)	(0.0297)
Observations	6,968	21,033
R-squared	0.811	0.752
Firm FE	YES	YES
Year FE	YES	YES
Controls	YES	YES

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results reveal a significant crowding-out effect exclusively among state-owned enterprises (SOEs). The *DID* coefficient for the SOE subsample is -0.155 ($p < 0.05$), suggesting a marked decline in green innovation output following the tax implementation. This suppression is primarily driven by the rigid environmental constraints and administrative accountability inherent to SOEs. Facing higher compliance costs, SOEs are compelled to divert limited funds toward immediate end-of-pipe treatments to meet political mandates, thereby crowdng out long-term green R&D investments. Thus, Hypothesis 2 (H2) is validated.

Conversely, the *DID* coefficient for private enterprises (-0.0390) remains statistically insignificant, indicating no substantial inhibition of their green innovation. Functioning under a profit-maximizing and market-oriented paradigm, private firms effectively absorb tax shocks through flexible operational adjustments, such as process optimization, factor reallocation, and cost pass-through. These market-based buffering mechanisms prevent the excessive diversion of R&D capital into inefficient end-of-pipe governance, allowing private firms to sustain their innovation momentum under compliance pressure, which empirically supports Hypothesis 3 (H3).

Overall, the policy effect is highly asymmetric: rigid political compliance induces a pronounced crowding-out effect in SOEs, while market-oriented resilience shields private firms from similar innovative stagnation.

5.4 Robustness Checks

Table 4: Robustness Checks

1.1	1.2 (1)	1.3 (2)
1.4 VARIABLES	1.5 Shorter Time Window	1.6 PSM-DID
1.7 DID	1.8 -0.0552*	1.9 -0.0825**
1.10	1.11 (0.0315)	1.12 (0.0344)
1.13 Size	1.14 0.469***	1.15 0.424***
1.16	1.17 (0.0443)	1.18 (0.0248)
1.19 Observations	1.20 11,401	1.21 25,107
1.22 R-squared	1.23 0.815	1.24 0.777
1.25 Firm FE	1.26 YES	1.27 YES
1.28 Year FE	1.29 YES	1.30 YES
1.31 Controls	1.32 YES	1.33 YES

Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

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Table 4 presents a battery of robustness checks to validate our baseline estimates. First, we narrow the event window to three years pre- and post-implementation to exclude potential unobservable long-term confounding factors. The *DID* coefficient remains negatively significant (-0.055, $p < 0.10$), confirming that our results are robust to alternative sample period specifications. Second, we utilize a Propensity Score Matching-DID (PSM-DID) framework to mitigate potential sample selection bias. After matching treatment and control firms based on pre-treatment characteristics, we re-estimate the model and obtain a *DID* coefficient of -0.083, which is significantly negative at the 5% level. This matched-sample estimation is highly consistent with our previous findings. Overall, the aforementioned tests confirm that the core conclusions of this study are highly robust, holding consistently across alternative temporal boundaries and methodologies addressing sample selection bias.

6. Conclusions and Policy Recommendations

Using the 2018 *Environmental Protection Tax Law* as a quasi-natural experiment, this study employs a DID framework on Chinese listed manufacturing firms (2012–2024) to evaluate the impact of environmental taxation on green innovation. Our findings are twofold: First, the tax shock induces a short-term crowding-out effect on aggregate green innovation output. Second, the impact is highly asymmetric across ownership structures, severely suppressing innovation in state-owned enterprises (SOEs) while leaving private firms relatively insulated.

These findings yield crucial policy and managerial implications. For the government, advancing environmental regulatory frameworks requires a structural shift from a single taxation tool to a comprehensive policy package. Policymakers should introduce complementary incentive schemes—such as supplementary green R&D deductions and targeted subsidies—to cushion the cash flow pressures of environmental mandates and prevent the crowding-out of crucial R&D funds. For the corporate sector, SOEs should optimize their internal governance by reducing the excessive assessment weight attached to short-term environmental compliance, thus encouraging management to focus on long-term technological upgrading. Ultimately, all enterprises must shift away from the myopic accumulation of low-quality "strategic" patents. By prioritizing substantive and high-quality green innovation, firms can seamlessly transform compliance costs into a competitive advantage, achieving a mutually beneficial outcome for both emission reduction and long-term firm value.

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