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The Impact of the Environmental Tax Policy on Corporate Value and Innovation: An Empirical Study Based on the DID Model

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Abstract: With the advancement of the "dual carbon" goal, the environmental tax, as an important instrument of environmental regulation, has drawn attention in both academia and practice regarding its impact on corporate operations and development. Using firm-level panel data from 2013 to 2023 as the research sample, this paper employs a difference-in-differences (DID) model, combined with parallel trend tests, mediation effect tests, and robustness tests, to systematically examine the impact of the environmental tax policy on corporate value. The findings show that: the environmental tax policy significantly enhances corporate market value; green innovation exerts both direct and indirect mediation effects in the impact of the environmental tax on corporate value. This paper provides empirical evidence and policy implications for optimizing the design of the environmental tax system and promoting corporate green innovation and value enhancement.

Keywords: Environmental tax, Difference-in-differences model, Corporate value, Green innovation, Mediation effect.

1. Introduction

With the development of reform and opening up, China's environmental problems have become increasingly severe and have become an important issue of widespread concern. As early as 1982, the Chinese government promulgated the Interim Measures for the Collection of Sewage Charges, establishing the sewage charging system in law and imposing charges on firms' pollution discharge behavior, so as to control the level of major pollutant emissions from industrial enterprises. Existing studies have found that sewage charges actively promoted the reduction of pollution emissions [1]. In recent years, China's ecological civilization construction has entered a critical stage and environmental regulation has been continuously strengthened. On December 25, 2016, China promulgated the Environmental Protection Tax Law of the People's Republic of China, which was officially implemented on January 1, 2018. As a core component of the "green tax system", the environmental tax aims, through the tax lever, to force firms to reduce pollutant emissions and promote green transformation. As the main actors in environmental governance, firms' production and operation, innovation decisions, and value creation will inevitably be affected by the implementation of the environmental tax policy. On the one hand, the environmental tax may increase firms' environmental governance costs, squeeze out R&D and production investment, and exert a short-term shock on corporate value; on the other hand, it may also force firms to increase green innovation investment, achieve cost reduction and efficiency gains through technological upgrading, and thereby enhance long-term value.

Existing studies are divided on the economic and environmental effects of the environmental tax: some scholars argue that the environmental tax can effectively incentivize corporate green innovation [2] and force firms to upgrade [3]; other studies point out that in the short term the environmental tax promotes technological progress of eco-friendly firms, thereby increasing output and consumption and reducing pollution emissions on the production side, while on the other hand it exerts a negative impact on total output and consumption [4]. Accordingly, this paper combines corporate value, financial performance, and green innovation to systematically investigate the multiple effects of the environmental tax rather than focusing on a single dimension; meanwhile, it uses panel data from 2013 to 2023, covering the complete cycle before and after the implementation of the environmental tax, which enhances the timeliness and representativeness of the research conclusions. Taking the implementation of the environmental tax policy as a natural experiment, this paper uses the DID model to empirically test its impact on corporate value, financial performance, and green innovation, and explores the mediating transmission mechanism of green innovation, so as to provide empirical support for resolving the above disputes and improving the environmental tax policy.

2. Literature Review and Theoretical Hypotheses

2.1. Environmental Tax and Corporate Economy

Research on the impact of the environmental tax on firms has roughly formed two opposing views. Some scholars hold that the implementation of the environmental tax increases firms' environmental governance and compliance costs, squeezing and restricting inputs such as R&D and production, thereby affecting firms' profitability. Using a CGE model, some scholars show that levying an environmental tax, while optimizing the energy consumption structure, brings a certain negative impact on the macroeconomy [5]. Meanwhile, some studies find that the current increase in China's environmental protection tax burden has not produced the "Porter effect"; instead, it creates a "negative incentive" for the development of regional green innovation capability and ultimately inhibits economic growth [6].

On the other hand, it is also a fairly common view that the implementation of the environmental tax forces firms to innovate and thereby promotes corporate economic

development [7] Research based on Shanghai and Shenzhen A-share markets confirms that the environmental tax can promote firm upgrading by affecting innovation input, and further influence corporate value [3]. In addition to microdata-based research, some scholars have also verified, using China's industrial economic data, the possibility that the environmental tax promotes corporate economic development [8, 9]. Beyond these two views, some scholars find that the implementation of the environmental tax has no significant effect on corporate performance in the short term [10, 11].

Based on this, this paper proposes its first theoretical hypothesis:

H1: The implementation of the environmental tax policy can significantly enhance corporate value.

2.2. Environmental Tax and Green Innovation

The relationship between the environmental tax and corporate green innovation is one of the hot topics in existing research. Most studies hold that the environmental tax can effectively incentivize corporate green innovation: by raising the cost of pollution emissions, the environmental tax forces firms to reduce pollutant emissions through technological innovation, thereby promoting the generation of green patents [12, 13]. Some scholars also find that the narrow environmental tax significantly promotes the increase in the number of technological innovations, and that its incentive effect is more pronounced for state-owned enterprises and for larger firms with insufficient cash flow [14]. A study focusing on listed companies shows that the implementation of the Environmental Protection Tax Law has a significant positive effect on the technological innovation efficiency of listed companies in the Beijing-Tianjin-Hebei region [15]. In contrast, a study incorporating the “tax burden transfer” method of the first year of collection points out that raising the sewage charge standard generally suppresses corporate innovation; however, when the environmental tax amount rises to a certain level, the collection of the environmental tax can promote firms' technological innovation [16]. In addition, some scholars conclude that the environmental protection tax inhibits corporate green technological innovation by suppressing environmental protection investment [17]. Similarly, earlier American scholars, based on the trend of productivity changes in the United States, proposed that the implementation of stringent environmental policies has, to a certain extent, constrained the pace of development of green technological innovation in the U.S. manufacturing industry [18].

Based on the above theories, this paper proposes the following research hypothesis:

H2: Green innovation plays a mediating role in the process by which the environmental tax policy enhances corporate value, that is, the environmental tax indirectly enhances corporate value by promoting green innovation.

2.3. Literature Review

Existing research has preliminarily explored the impact of the environmental tax on corporate value and green innovation, but there remain some shortcomings: first, most studies focus only on the impact of the environmental tax on a single variable and fail to incorporate corporate value, financial performance, and green innovation into the same analytical framework, ignoring the possible transmission relationships among the three; second, some existing literature does not explore the mediating mechanism of green innovation in sufficient depth and fails to clarify the specific path through which the environmental tax affects corporate value via green innovation. Finally, constrained by the timing of policy implementation, existing research finds it difficult to conduct a complete before-and-after comparison of the environmental tax policy. Accordingly, using China's A-share data from 2013 to 2023, this paper adopts the DID model combined with mediation effect tests to systematically investigate the impact of the environmental tax on corporate value, financial performance, and green innovation, thereby filling the gaps in existing research.

3. Empirical Research Design

3.1. Sample Selection and Data Sources

This paper selects China's firm-level panel data from 2013 to 2023 as the research sample. To ensure the reliability of the research results, the sample is screened as follows: (1) financial industry firms are excluded because their business models differ significantly from those of other industries; (2) ST and *ST firms are excluded to avoid the influence of outliers; (3) firms with severe missing data are excluded; (4) all continuous variables are winsorized at the 1% and 99% percentiles to mitigate the influence of extreme values. Ultimately, 61,565 observations are obtained, covering 6,608 firms.

The data used in this paper all come from public sources: green patent data are from the patent database of the China National Intellectual Property Administration; corporate financial data (Tobin's Q, firm size, etc.) are from the Guotaian (CSMAR) database; data on firm ownership nature, industry classification, etc. are from the Wind database. All data have been collated and verified to ensure their authenticity and completeness.

3.2. Variable Definitions

3.2.1. Dependent Variables

The dependent variables in this paper include corporate value and green innovation:

(1) Corporate value: measured by Tobin's Q, where Tobin's Q = corporate market value / corporate book value, reflecting the market value and growth potential of the firm; the higher the value, the higher the corporate value.

(2) Green innovation: measured by the natural logarithm of the number of green patents, including green invention patents and green utility model patents, reflecting the firm's green innovation capability; the higher the value, the higher the level of green innovation.

3.2.2. Core Explanatory Variable

The core explanatory variable is the difference-in-differences variable (DID), which is used to measure the shock of the environmental tax policy. Since the environmental tax was officially implemented in 2018, the post-policy years (2018 and later) are set to 1, and the years before 2018 to 0; the treatment group comprises firms strongly affected by the environmental tax policy, namely pollution-intensive firms, coded as 1, while the control group comprises firms in non-pollution-intensive industries, coded as 0. did = treatment group × post-policy year; if did = 1, it indicates that the firm was subject to the shock of the environmental tax policy after implementation; if did = 0, it indicates that the firm was not subject to the policy shock or that the observation is before implementation.

3.2.3. Control Variables

To control for the influence of other factors on the dependent variables, and referring to existing research [19], the following control variables are selected:

(1) Firm size (Size): measured by the natural logarithm of total assets, reflecting the scale effect of the firm; larger firms have more abundant resources and may be better able to cope with the shock of the environmental tax.

(2) Return on equity (Roe): Roe = net profit / net assets, reflecting the firm's profitability; the stronger the profitability, the stronger the firm's ability to resist risks.

(3) Cash flow (Cashflow): measured by the ratio of net cash flow from operating activities to total assets, reflecting the firm's cash flow situation; firms with sufficient cash flow are more likely to invest in green innovation and environmental governance.

(4) Ownership nature (Soe): a dummy variable, coded as 1 for state-owned enterprises and 0 for non-state-owned enterprises; firms with different ownership natures may respond differently to environmental policies.

In addition, this paper controls for year fixed effects to mitigate the influence of annual factors such as the macroeconomic environment and policy changes, and controls for firm individual fixed effects to mitigate the influence of unobserved firm-specific characteristics.

3.3. Model Specification

3.3.1. Baseline DID Model

To test the direct impact of the environmental tax policy on corporate value, financial performance, and green innovation, the following two-way fixed-effects DID model is constructed:

$$Y_{it} = \alpha_0 + \alpha_1 did_{it} + \alpha_2 Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where Y_{it} is the dependent variable, namely Tobin's Q (Tobinq); did_{it} is the core explanatory variable, the difference-in-differences variable; $Controls_{it}$ is the set of control variables; μ_i is the firm individual fixed effect; λ_t is the year fixed effect; ε_{it} is the random disturbance term; α_0 is the constant term; α_1 is the core coefficient, which reflects the extent of the impact of the environmental tax policy on the dependent variable. If α_1 it is significantly positive, the environmental tax policy promotes an increase in the dependent variable; otherwise, it suppresses it.

3.3.2. Mediation Effect Model

To test the mediating role of green innovation between the environmental tax and corporate value, and referring to the mediation effect test method of Wen Zhonglin et al. (2004) [20], the three-step model of Equations (2), (3), and (4) is constructed as follows:

$$Tobinq_{it} = \gamma_0 + \gamma_1 did_{it} + \gamma_2 Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

$$Green_Patent_{it} = \delta_0 + \delta_1 did_{it} + \delta_2 Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

$$Tobinq_{it} = \theta_0 + \theta_1 did_{it} + \theta_2 Green_Patent_{it} + \theta_3 Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

Where $Green_Patent_{it}$ is the green innovation index of firm i in year t, i.e., the mediating variable. The other variables are consistent with Equation (1). Equation (2) tests the total effect of the environmental tax on corporate value, which is essentially still the baseline DID model; Equation (3) verifies the effect of the environmental tax on the mediating variable; finally, Equation (4) includes both the core explanatory variable and the mediating variable, testing the direct and mediating effects of green innovation on corporate value.

4. Empirical Results Analysis

4.1. Descriptive Statistics

Table 1 reports the descriptive statistics of the main variables. From the statistical results, the mean of Tobin's Q (Tobinq) is 3.7856 with a standard deviation of 2.6941, indicating certain differences in market value across firms; the mean of the number of green patents (Green_Patent) is 0.2541 with a standard deviation of 0.5886, and the gap between the maximum and minimum is large, indicating significant differences in the level of green innovation across firms. The mean of the core explanatory variable did is 0.4607. The value ranges of the control variables are basically consistent with existing research, with no abnormal values, and the data are overall reasonable.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std.	Min	Max
Tobinq	10,318	3.7856	2.6941	0.9747	11.1594
did	10,318	0.4607	0.4985	0.0000	1.0000
Green_Patent	10,318	0.2541	0.5886	0.0000	2.9444
Size	10,240	21.4791	0.9512	19.9584	23.4645
Roe	10,318	3.6891	4.7939	-6.2073	14.1179
Cashflow	10,318	0.1659	0.5090	-0.8100	1.3700
Soe	10,318	0.3694	0.4827	0.0000	1.0000

4.2. Parallel Trend Test

The parallel trends assumption is the core premise for the validity of the DID model. This paper selects 2018, when the policy officially took effect, as the zero time point and tests the parallel trends assumption through a dynamic effect model, with the results shown in Figure 1 below: in the five years before the policy (pre5–pre1), apart from the significant coefficient of pre3, the other coefficients are all insignificant, and the overall trend is consistent, so the parallel trends assumption holds, indicating that the DID model setting in this paper is reasonable and further analysis can be conducted.

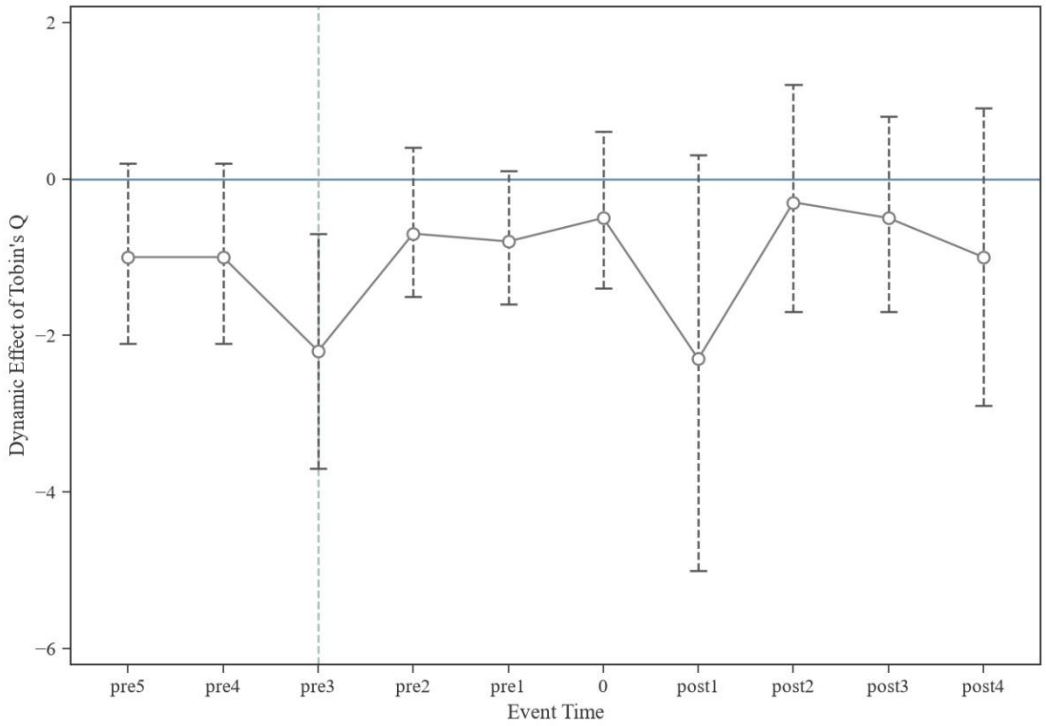


Figure 1. Parallel Trend Test

4.3. Baseline Regression Results Analysis

Table 2 reports the baseline DID regression results of the environmental tax policy on corporate value, financial performance, and green innovation. From the regression results:

Table 2. Baseline Regression Analysis

Variable	Tobinq
did	0.520***
	(0.201)
Size	-2.850***
	(0.158)
Roe	0.0361***
	(0.00798)
Cashflow	0.172***
	(0.0475)
Soe	-0.0942
	(0.414)
_cons	62.97***
	(3.287)
N	10240
adj. R^2	0.398

Note: Standard errors are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Impact of the environmental tax on corporate value (Tobin's Q): the coefficient of did is 0.5197, significant at the 5% level ($p = 0.010$), indicating that the implementation of the environmental tax policy significantly enhances firms' market value, and hypothesis H1 is partially verified. As for the control variables, firm size has a significant positive effect on both green patents and Tobin's Q, indicating that larger firms have higher green innovation capability and market value; return on equity has a significant positive effect on Tobin's Q, indicating that more profitable firms have higher market value; cash flow has a positive effect on both green patents and Tobin's Q, indicating that firms with sufficient cash flow are more likely to invest in green innovation and value enhancement; ownership nature has no significant effect on any of the three dependent variables, indicating that there is no significant difference between state-owned and non-state-owned firms in their response to the environmental tax policy.

4.4. Mediation Effect Test Results

Using green patents as the mediating variable, this paper tests their transmission role between the environmental tax and corporate value; the regression results are shown in Table 3:

The first column verifies the impact of the environmental tax on Tobin's Q, where the coefficient of did is 0.520, significant at the 1% level, indicating that the environmental tax policy significantly enhances corporate value, consistent with the baseline regression results. The second column examines the impact of the environmental tax on green patents, where the coefficient of did is 0.062, significant at the 1% level, indicating that the direct impact of the environmental tax on green patents is significant. In the third column, the coefficient of did is 0.519, representing a direct effect of 0.519, significant at the 1% level, with an indirect effect also present. The coefficient of green innovation is 0.203, significant at the 1% level. The direct effect of the environmental tax on green patents is significantly positive, and green patents significantly enhance corporate value, indicating that green innovation plays a partial mediating role and that the environmental tax can indirectly enhance corporate value by guiding firms' green innovation; hypothesis H2 is supported.

Table 3. Mediation Effect Test

Variable	Tobinq	Green_Patent	Tobinq
Green_Patent	-	-	0.203***
	-	-	(0.068)
did	0.520***	0.062***	0.519***
	(0.201)	(0.0129)	(0.201)
Size	-2.850***	0.139***	-2.869***
	(0.158)	(0.0149)	(0.158)
Roe	0.0361***	-0.00292***	0.0363***
	(0.00798)	(0.00064)	(0.00797)
Cashflow	0.172***	0.0177**	0.170***
	(0.0475)	(0.00718)	(0.0476)
Soe	-0.0942	-0.0327	-0.0939
	(0.414)	(0.0591)	(0.411)
_cons	62.97***	-2.736***	63.36***
	(3.287)	(0.322)	(3.283)
N	10240	10240	10240

Note: Standard errors are reported in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

4.5. Robustness Tests

To ensure the reliability of the research conclusions, this paper conducts robustness tests using three methods: a placebo test, excluding the abnormal year, and 5% winsorization. The results are shown in Table 4:

Table 4. Robustness Tests

	(1)	(2)	(3)	(4)
Variable	Tobinq	Tobinq	Tobinq	Tobinq
did	0.520***	-	0.544**	0.356***
	(0.201)	-	(0.221)	(0.123)
did_fake	-	0.735***	-	-
	-	(0.231)	-	-
Size	-2.850***	-2.830***	-2.886***	-1.985***
	(0.158)	(0.158)	(0.160)	(0.0924)
Roe	0.0361***	0.0360***	0.0344***	0.0968***
	(0.00798)	(0.00797)	(0.00837)	(0.00633)
Cashflow	0.172***	0.170***	0.208***	0.0622
	(0.0475)	(0.0478)	(0.0519)	(0.0482)
Soe	-0.0942	-0.0737	-0.113	-0.0338
	(0.414)	(0.413)	(0.433)	(0.235)
_cons	62.97***	62.56***	63.75***	44.64***
	(3.287)	(3.294)	(3.340)	(1.933)
N	10240	10240	9263	10240

Note: Standard errors are reported in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Among them, column (1) represents the baseline regression results, and column (2) represents the placebo test results, in which this paper moves the policy implementation year forward to 2016 and completes the placebo test by constructing a fake difference-in-differences variable (did_fake). The regression results show that the coefficient of did_fake is significant but significantly different from the coefficient of did in the baseline regression, indicating thatthe baseline regression results are not driven by other factors such as time trends, that the true effect of the environmental tax policy exists, and that the results are robust. Column (3) excludes the data of 2018 (the year the environmental tax was officially implemented) and conducts regression analysis; the obtained coefficient of did is 0.5443, significant at the 5% level, consistent with the baseline regression results, indicating that the abnormal year does not affect the research conclusions and the results are robust. Column (4) represents winsorizing all continuous variables at 5% and re-running the regression; the coefficient of did is 0.3558, significant at the 1% level, consistent in direction with the baseline regression results, indicating that extreme values do not affect the research conclusions and the results are robust. In summary, all three robustness tests are passed, indicating that the research conclusions of this paper are highly reliable.

5. Research Conclusions and Policy Recommendations

5.1. Research Conclusions

Using firm-level panel data from 2013 to 2023 as the sample, this paper adopts the DID model, combined with parallel trend tests, mediation effect tests, and robustness tests, to systematically investigate the impact of the environmental tax policy on corporate value, financial performance, and green innovation, and draws the following conclusions:

First, the environmental tax policy significantly enhances firms' market value and financial performance. The baseline regression results show that the coefficient of did is significantly positive for both Tobin's Q and annual return, indicating that the implementation of the environmental tax policy can effectively enhance firms' market value and profitability, which verifies the view of the “innovation compensation theory”, namely that the environmental tax forces firms to optimize production models and improve efficiency, thereby achieving the enhancement of corporate value and performance.

Second, the direct promoting effect of the environmental tax policy on corporate green innovation is not significant. The baseline regression results show that the coefficient of did is insignificant for green innovation, indicating that the environmental tax policy fails to directly incentivize firms to increase green innovation investment. The possible reasons are: the tax rate of the environmental tax is not set reasonably enough and fails to form an effective incentive mechanism; corporate green innovation requires large investment and a long cycle, making it difficult to see results in the short term; and some firms prefer to respond to the shock of the environmental tax through end-of-pipe treatment rather than technological innovation.

Third, green innovation plays a partial mediating role in the process by which the environmental tax enhances corporate value. The mediation effect test results show that although the direct impact of the environmental tax on green innovation is insignificant, green innovation can significantly enhance corporate value, indicating that the environmental tax policy can indirectly promote green innovation and thereby enhance corporate value; that is, green innovation is an important transmission channel through which the environmental tax affects corporate value.

5.2. Policy Recommendations

Based on the above research conclusions, this paper proposes the following policy recommendations to provide a reference for improving the environmental tax policy and promoting corporate green transformation and high-quality development:

First, optimize the design of the environmental tax policy

and strengthen the incentive effect of the policy. Reasonably adjust the environmental tax rate and implement differentiated tax rates according to the degree of industry pollution, raising the tax rate for pollution-intensive industries to form effective incentives; provide preferential policies such as tax reductions and exemptions and financial subsidies to firms that actively engage in green innovation, so as to reduce the cost of corporate green innovation and stimulate firms' enthusiasm for green innovation.

Second, guide firms to increase green innovation investment and enhance green innovation capability. The government should strengthen its guidance and support for corporate green innovation, improve the protection system for green innovation, and encourage firms to carry out green technology R&D and transformation; firms should change their development concepts, incorporate green innovation into their long-term development strategies, increase green R&D investment, improve green production technology, and achieve cost reduction, efficiency gains, and value enhancement through green innovation.

Third, improve the supporting policy system and strengthen the synergy effect of the environmental tax policy. Strengthen the coordination and cooperation between the environmental tax and environmental supervision, industrial policy, and fiscal policy to form a policy synergy; establish and improve the corporate environmental information disclosure system, strengthen social supervision, force firms to fulfill their environmental responsibilities, and promote corporate green transformation.

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