

# ***The Effect of Environmental Tax on Corporate Green Innovation: Incremental Quality Improvement in the Carbon Emission Trading Market***

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**Abstract:** This study examines how environmental tax influences corporate green technological innovation, with a particular focus on “incremental quality improvement.” Using empirical data from A-share listed companies in Shanghai and Shenzhen spanning from 2018 to 2022, the research controls for key variables such as company size and total debt ratio. The analysis explores the direct relationship between environmental tax and corporate innovation in green technologies. In addition, it considers the moderating role of carbon emission trading market policies in shaping this relationship. The findings indicate that environmental tax plays a crucial role in fostering incremental improvements in the quality of green technological innovation, primarily through innovation compensation mechanisms and the effect of compliance costs. More specifically, a 1% increase in environmental tax correlates with a notable rise of 3.132 units in the number of green technological innovations, as well as an increase of 2.848 units in their quality. The study further reveals that in regions where carbon emission trading policies are active, the positive influence of environmental taxes on green innovation is significantly amplified. These results provide valuable insights for enhancing environmental tax strategies and reinforcing the integration between carbon emission trading markets and environmental taxation. Such synergies can help drive corporate innovation in green technologies and contribute to the achievement of broader sustainable development goals.

**Keywords:** Environmental Tax, Green Technological Innovation, Carbon Emission Trading Market

## **1. Introduction**

In the report of the 20th National Congress of the Communist Party of China, the concept of “Chinese-style modernization” was expanded to include the notion of “modernization in harmony between humanity and nature.” This addition further clarified the strategic priorities for ecological civilization construction in the new era. At present, the central focus of ecological civilization construction is the promotion of green development, with the ultimate goal of achieving a harmonious relationship between humans and the environment. However, the reality of the situation is that various pollutants continue to be discharged at increasing rates, and this growing environmental degradation has become a significant challenge for China in balancing economic growth with ecological sustainability. From a microeconomic perspective, enterprises play a central role as key

contributors to innovation. In this context, environmental taxes are a critical policy instrument designed to encourage businesses to adopt environmentally friendly practices in their operations. These taxes influence not only the quantity of green technological innovations but also their overall quality. Consequently, fostering corporate green technological innovation to achieve both “quantitative growth” and “quality enhancement” is an essential step toward promoting high-quality, sustainable economic development.

## 2. Literature Review and Research Hypotheses

### 2.1. Literature Review

The exploration of the relationship between environmental taxes and technological innovation has a long-standing academic tradition, dating back to the introduction of the well-known “Porter Hypothesis” in 1995. This hypothesis has sparked extensive debate and research, giving rise to three predominant perspectives on how environmental taxes interact with technological innovation.

The first perspective challenges the Porter Hypothesis, positing that environmental taxes may have a detrimental effect on technological innovation in businesses. For instance, Liu Liang and colleagues argued that environmental protection taxes can inhibit green technological advancements, particularly within the chemical industry [1]. This view suggests that the financial burden of environmental taxes may discourage companies from investing in new technologies. In contrast, the second perspective affirms the Porter Hypothesis, suggesting that moderate environmental regulations can foster technological innovation. According to Rubashkina and others, the introduction of stricter environmental tax policies positively impacts technological innovation in manufacturing firms, particularly in countries with targeted policies [2]. This viewpoint highlights the potential of well-designed environmental regulations to stimulate innovation, particularly when the regulatory framework is appropriately calibrated. The third perspective contends that the relationship between environmental taxes and innovation is not linear, but rather contingent upon the intensity of the regulations. Liu Jinru and colleagues found that low-intensity environmental regulations fail to motivate enterprises to innovate. However, as the intensity of regulation increases, its effect gradually shifts, becoming more positive once a certain threshold is crossed [3]. This perspective suggests that environmental taxes may only be effective in promoting innovation when they are sufficiently stringent.

Moreover, some scholars have pointed out the nonlinear dynamics between environmental regulation and innovation. Ramanathan and his team examined this relationship over time and concluded that environmental regulation has a “U-shaped” impact on corporate green technological innovation [4]. According to their findings, the effect of environmental regulation on innovation tends to be initially negative but becomes positive after a certain point, reflecting the complex and evolving nature of this relationship. In addition to these primary perspectives, a growing body of research has acknowledged that external and internal factors can influence the effectiveness of environmental taxes in promoting innovation. Studies have shown that elements such as the quality of government institutions [5] and the internal control mechanisms of corporate leadership [6] play a significant role in shaping how environmental taxes impact innovation incentives. These factors suggest that the overall regulatory environment and firm-specific characteristics can either amplify or dampen the innovation-boosting potential of environmental taxes.

A review of existing literature identifies several notable gaps in the current body of research. First, the majority of previous studies have concentrated on exploring the broad relationship between environmental taxes and green technological innovation. However, these studies often fail to differentiate between the quantity and the quality of green technological innovations, overlooking important nuances in how environmental taxes influence these two dimensions of innovation. Second,

empirical research on this topic remains limited, with much of the existing work focusing primarily on macro-level analyses. There is a notable lack of in-depth studies that examine how environmental taxes affect technological innovation at the level of individual firms, leaving a significant gap in our understanding of the microeconomic implications. Furthermore, much of the extant research has tended to evaluate the general effects of environmental taxes or broader environmental regulations on innovation, without sufficiently investigating the interplay between environmental taxes and specific core policies, such as carbon emission trading markets. This gap in the literature signals the need for more focused research that considers these interactions and their potential to shape green technological innovations more effectively.

## 2.2. Research Hypotheses

In the context of sustainable development, environmental taxes serve as an important policy tool that influences corporate green technological innovation. These taxes affect innovation through two key channels: innovation compensation and compliance cost effects. By deferring pollution control payments, companies can lower compliance costs, and in a competitive market, the innovation compensation effect can be more effectively utilized [7]. As firms recognize the increasing stringency and permanence of environmental policies, they are incentivized to ramp up their innovation efforts in order to survive and thrive. This leads to greater investment in green technology R&D and an increase in the number of green innovations. Meanwhile, as green development concepts gain traction, consumer demand for green products rises, and shareholders push managers to prioritize green innovation. For businesses, improving the quality of green technological innovation is crucial for gaining market advantages, ensuring environmental protection, and enhancing competitiveness. Based on this, the following hypothesis is proposed:

H1: Environmental tax significantly promotes the “incremental quality improvement” of corporate green technological innovation.

In areas where the carbon emission trading market policy is in place, the interaction between carbon emission trading and environmental taxes further intensifies the cost pressures on firms, which can, in turn, influence their green technological innovation strategies. Policy guidance encourages companies to realign their strategies and increase R&D expenditures, seeking competitive advantages while aiming to reduce costs and improve innovation quality. At the same time, rising consumer demand for green products and the growing expectations of shareholders for sustainable long-term value push companies to enhance the quality of their innovation. As a result, these companies achieve a balanced development of environmental protection and business competitiveness. Building on this premise, the following hypothesis is advanced:

H2: In regions where the carbon emission trading market policy is implemented, the effect of environmental tax on “incremental quality improvement” in corporate green technological innovation is more significant.

## 3. Research Design

### 3.1. Sample Selection and Data Sources

In 2024, the Ministry of Ecology and Environment of the State Council underscored the importance of prioritizing green and low-carbon transformation, enhancing equipment upgrades, expanding environmental governance services, and promoting ecological technology support within the environmental protection sector. Concurrently, the “Industry Classification Guidelines for Listed Companies” have contributed to improving the accuracy and reliability of statistical analyses of listed companies’ data. Based on these considerations, this study focuses on A-share listed companies in Shanghai and Shenzhen between 2018 and 2022. Following the exclusion of companies categorized

as ST, \*ST, PT, as well as those with substantial missing data that could not be substituted, a total of 9,332 observations were included in the final sample. The data utilized in this analysis is derived from the CSMAR database. To mitigate the impact of extreme values on the results, a 1% Winsorization treatment was applied to the continuous variables.

### 3.2. Variable Definitions

**Dependent Variables:** Green Technological Innovation Number (GIN) and Green Technological Innovation Quality (GIQ). Since the patent approval process is relatively lengthy, this study uses the total number of green patent applications as a measure of the number of green technological innovations (GIN). The effectiveness of green patents significantly improves with the number of citations they receive, indicating that the number of citations reflects the impact and technical level of green patents. Specifically, the more frequently a patent is cited, the higher the quality of green technological innovation (GIQ) [8]. Therefore, this study uses the citation count of green patents within five years to measure the quality of green technological innovation (GIQ).

**Independent Variable:** Environmental Tax (LnET). This study uses the environmental protection tax paid by listed companies and applies a logarithmic transformation.

**Control Variables:** From the perspective of the companies themselves, this study controls for six major variables that may affect their green innovation activities: Company Size (Size), Total Debt Ratio (Asset), Return on Assets (Roa), Proportion of Independent Directors (Indep), Price-to-Book Ratio (Pb), and Revenue Growth Rate (Growth) [9]. The specific definitions and explanations of these variables are detailed in Table 1.

Table 1: Variable Definitions and Explanations

Variable Type	Variable Name	Variable Symbol	Variable Explanation
Dependent Variables	Green Technological Innovation Number	GIN	Total number of green patent applications
	Green Technological Innovation Quality	GIQ	Number of citations within 5 years for green patents
Independent Variable	Environmental Tax	LnET	Logarithm of the environmental protection tax amount
Control Variables	Company Size	Size	Logarithm of total assets
	Total Debt Ratio	Asset	Total assets / total liabilities
	Return on Assets	Roa	Net profit / total assets
	Proportion of Independent Directors	Indep	Proportion of independent directors in the board
	Price-to-Book Ratio	Pb	Market value of the company / total assets
	Revenue Growth Rate	Growth	Market value of the company / total assets

### 3.3. Model Construction

$$GIN = \alpha_0 + \beta_1 LnET_{i,t} + \beta_n Controls_{i,t} + u_i + \varepsilon_{i,t}$$

$$GIQ = \alpha_0 + \beta_1 LnET_{i,t} + \beta_n Controls_{i,t} + u_i + \varepsilon_{i,t}$$

In the model,  $i$  and  $t$  represent the company and time, respectively,  $u_i$  indicates individual factors that do not change over time,  $\varepsilon_{i,t}$  is the random error term,  $\alpha_0$  is the intercept,  $\beta$  represents the parameters to be estimated, and *Controls* refers to the set of control variables.

## 4. Empirical Results Analysis

### 4.1. Baseline Regression Analysis

The Hausman test results indicate a p-value of 0.0000, which is well below the 0.01 threshold. This supports the use of a fixed effects model, confirming that such a model is appropriate for this analysis.

As presented in Table 2, the baseline regression results investigate the effect of environmental tax (LnET) on the number (GIN) and quality (GIQ) of green technological innovations within firms. The findings reveal that environmental tax has a statistically significant and positive effect at the 1% level. Specifically, an increase of 1% in environmental tax is associated with an increase of 3.132 units in the number of green technological innovations and 2.848 units in the quality of these innovations. This confirms that environmental taxes can play a substantial role in boosting both the quantity and quality of green technological innovations in businesses, thereby supporting hypothesis H1. In terms of control variables, the regression results align with the anticipated patterns. The total debt ratio of a company shows a significantly positive coefficient, implying that higher levels of debt are correlated with reduced capabilities in green technological innovation. This might be attributed to the financial strain and limited liquidity resulting from high debt, which reduces the company's capacity to invest in innovation or secure funds for research and development. Furthermore, the prioritization of short-term financial goals, fragmented management focus, and lower willingness to take risks or pursue innovation likely contribute to the suppression of green technological advancements. On the other hand, the coefficient for revenue growth rate is positive, suggesting that firms experiencing robust growth and strong market competitiveness are more likely to foster green transformation and enhance their green technological innovation efforts.

Table 2: Regression Analysis Results

Variable	Model (1) GIN	Model (2) GIQ
LnET	3.132*** (3.15)	2.848*** (7.51)
Size	2.075 (1.37)	-1.190 (-1.12)
Asset	-7.419 (-1.64)	-5.628 (-1.28)
Roa	-17.62** (-2.33)	-20.77*** (-2.85)
Indep	-0.0138 (-0.15)	0.0535 (0.61)
Pb	0.00541 (0.03)	-0.0146 (-0.08)
Growth	4.566*** (2.97)	2.566* (1.73)
Individual	Fixed	Fixed
Industry	Fixed	Fixed
Time	Fixed	Fixed
_cons	-78.46** (-2.48)	-8.979 (-0.33)
N	9332	9332
R <sup>2</sup>	0.013	0.012

#### 4.1.1. Further Analysis Based on the Carbon Emission Trading Market

The national carbon emission trading market is a pivotal policy instrument aimed at reaching the carbon peak and carbon neutrality objectives. For this analysis, we focus on listed companies operating in nine key regions—Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong, Shenzhen, Sichuan, and Fujian—where carbon emission trading markets are implemented. These regions are considered to be influenced by the carbon emission trading market policy, while other areas are categorized as unaffected. As indicated in columns (1) and (3) of Table 3, the regression analysis reveals that for firms operating within regions impacted by the national carbon emission trading market policy, the environmental tax coefficient is both positive and statistically significant at the 1% level. In contrast, the results in columns (2) and (4) show that for companies outside the scope of this policy, the environmental tax's effect on the quality of green technological innovation is not statistically significant. Additionally, the impact on the number of innovations is noticeably weaker compared to companies in regions subject to the policy. These findings suggest that environmental taxes exert a more substantial and positive influence on companies within the carbon emission trading market, fostering both the quantity and quality of their green technological innovations. This outcome provides strong support for the validity of hypothesis H2.

Table 3: Heterogeneity Test Results of Carbon Emission Trading Market Policy

Variable	Model (1) GIN	Model (2) GIN	Model (3) GIQ	Model (4) GIQ
LnET	6.545*** (2.96)	0.869 (1.48)	3.595*** (4.48)	2.227*** (7.73)
Size	-2.035 (-0.59)	4.935*** (5.69)	-1.777 (-0.76)	-1.115 (-1.41)
Asset	-8.634 (-0.85)	-6.584** (-2.49)	-10.86 (-1.14)	-1.577 (-0.48)
Roa	-19.03 (-1.19)	-16.72*** (-3.61)	-25.92* (-1.76)	-17.96*** (-3.13)
Indep	-0.113 (-0.58)	0.0691 (1.31)	0.166 (0.91)	-0.0420 (-0.63)
Pb	-0.237 (-0.58)	0.229** (2.02)	-0.00682 (-0.02)	0.00636 (0.05)
Growth	5.584 (1.64)	3.576*** (3.93)	2.428 (0.77)	3.085*** (2.71)
Individual	Fixed	Fixed	Fixed	Fixed
Industry	Fixed	Fixed	Fixed	Fixed
Time	Fixed	Fixed	Fixed	Fixed
_cons	-24.70 (-0.32)	-116.2*** (-6.53)	-3.528 (-0.06)	-1.810 (-0.09)
N	3932	5400	3932	5400
R <sup>2</sup>	0.014	0.038	0.010	0.023

## 5. Research Conclusions and Policy Recommendations

### 5.1. Research Conclusions

This research, which utilizes data from listed companies on the Shanghai and Shenzhen A-shares market between 2018 and 2022, investigates how environmental taxes influence corporate green technological innovation. It also examines the moderating effect of carbon emissions trading market

policies on this relationship. Through a comprehensive empirical analysis, the study presents the following findings:

Environmental taxes play a crucial role in encouraging companies to invest in green technology research and development (R&D) by activating two key mechanisms: the innovation compensation effect and the compliance cost effect. These mechanisms provide both financial incentives and cost-saving opportunities, leading firms to boost their green technological R&D investments. As a result, the number and quality of green technological innovations are enhanced, contributing to a measurable improvement in the “incremental quality improvement” of these innovations within the corporate sector.

Moreover, in regions where carbon emissions trading market policies are in place, the impact of environmental taxes on green technological innovation is even more pronounced. The interaction between these policies and environmental taxes creates a synergistic effect that amplifies the cost pressures on companies. In response, firms are motivated to leverage technological innovation not only to reduce environmental costs but also to strengthen their market position and enhance their overall competitiveness. This finding underscores the significant role of carbon emissions trading policies in driving the dual objectives of environmental protection and corporate innovation.

## 5.2. Policy Recommendations

### 5.2.1. Improve Environmental Tax Policy to Encourage Green Technological Innovation

To foster greater innovation in green technologies and curb pollution, the government should refine its environmental tax policies. This includes setting tax rates at levels that are both high enough to effectively discourage harmful environmental practices by companies and supportive enough to incentivize investment in green technological advancements. Additionally, the government can enhance the effectiveness of these policies by providing targeted tax incentives, grants, and subsidies. These measures would not only encourage companies to increase their investments in research and development of environmentally friendly technologies but also improve the overall quality of their green innovations, thereby benefiting both the environment and corporate competitiveness.

### 5.2.2. Strengthen the Synergy Between Carbon Emissions Trading Market and Environmental Tax

The interaction between the carbon emissions trading market and environmental taxes plays a pivotal role in driving corporate green technological innovation. By leveraging the combined influence of these policies, companies are motivated to reduce their carbon footprints and adopt innovative low-carbon technologies. Therefore, the government should focus on expanding the scope of the carbon emissions trading market, improving its efficiency, and ensuring that it is closely aligned with environmental tax policies. This alignment will create a more robust policy framework that encourages companies to pursue low-carbon transformation strategies through technological innovation, contributing to the achievement of broader environmental and economic goals.

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