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Pursuing Cleaner Skies: A Study on the Impact of China's Environmental Protection Tax Law on Haze Pollution

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Abstract: Haze pollution control is integral to green development, and fiscal and taxation policies are fundamental mechanisms supporting this effort. This study leverages the implementation of China's Environmental Protection Tax (EPT) Law as a quasi-natural experiment to assess the impact and mechanisms of the greening of the tax system on haze pollution based on panel data from 281 prefecture-level cities in China from 2012 to 2021. The findings indicate that (1) the implementation of the EPT Law significantly reduces haze pollution, with results confirmed after a series of robustness tests; (2) the EPT Law controls haze pollution through promoting cleaner industrial structure, fostering green technological innovation, and strengthening the rigidity of environmental law enforcement; (3) fiscal decentralization enhances the inhibitory effect of the implementation of the EPT Law on haze pollution; (4) the haze-reduction effect of the EPT Law is especially notable in non-old industrial bases, areas with less pressure on officials' promotions, and areas with higher public environmental awareness. This study not only enriches research on the policy effects of the EPT Law but also contributes to the environmental sustainable development goal of greening the tax system and continuously fighting for blue skies.

Keywords: haze pollution; Environmental Protection Tax Law; industrial structure; green technological innovation; rigidity of environmental law enforcement

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1. Introduction

As global climate change and environmental challenges escalate, green development has become a pivotal concern for governments and organizations worldwide [1,2]. In China, rapid industrialization and urbanization since the early 21st century have caused frequent haze episodes, primarily driven by fine particulate matter (PM2.5), which poses a significant threat to public health and hampers the country's progress towards sustainable economic development [3–5]. In response, the Chinese government has taken decisive actions to combat air pollution, aligning with global efforts for green development and ecological preservation. A series of measures, including the "Air Pollution Prevention and Control Action Plan" (2013) and the "Three-Year Action Plan for Winning the Blue-Sky Defense" (2018), have led to improved air quality and a notable decrease in heavily polluted days [6]. According to the latest data from the Ministry of Ecology and Environment, the average PM2.5 concentration in China's prefecture-level and above cities reached 30 $\mu g/m^3$ in 2023, still three times the World Health Organization's recommended standard, indicating that haze control remains a significant challenge in China.

Due to the complexity of haze governance [7], establishing a diversified framework that includes administrative intervention, economic incentives, market mechanisms, legal safeguards, and technological innovation is crucial. Fiscal and taxation policies, as economic regulatory tools, aim to curb uncontrolled atmospheric pollutant emissions at the source by influencing polluters' behavior. The implementation of the Environmental Protection Tax (EPT) Law of the People's Republic of China in January 2018 marked a significant milestone in transforming China's tax system toward green and sustainable development. This law replaced the previous pollution charge system, aligning with the principle of “tax burden shifting” [8]. It designates producers and operators who directly discharge taxable pollutants into the environment as tax-paying entities, categorizes atmospheric pollutants as taxable, and sets quantitative limits on atmospheric pollution emissions [9]. The EPT Law encourages enterprises to shift from passive to proactive pollution reduction, improving air quality by reducing atmospheric pollutant emissions [10]. As atmospheric pollutants are a primary component of haze, this law provides innovative legal pathways for mitigating haze pollution. This study analyzes the impacts of the EPT Law on haze pollution and examines its mechanism as China’s first individual tax law embodying the “green tax system”. It has substantial implications for enhancing the green tax system’s benefits and fostering green prosperity through sustainable economic growth.

Research on haze pollution is generally categorized into three main areas. The first category focuses on the measurement of haze pollution. Fields such as environmental engineering, physics, chemistry, and optics often use scientific experiments to analyze specific haze pollution events from micro-perspectives, including composition [11,12] and visibility [13,14]. Due to disciplinary limitations, economists typically rely on readily available or convertible data for haze pollution studies. PM2.5, a primary indicator of haze pollution, is the most frequently used metric to quantify it [15]. The second category examines the economic implications of haze pollution, including its impact on high-quality economic development [16], green technological innovation [17], and green total factor productivity [18]. The third category explores various factors influencing haze pollution mitigation. The existing literature analyzes the effects, spatial characteristics, and mechanisms of factors such as industrial structure [19], urbanization [7], and transportation infrastructure [20] on haze pollution. However, studies focusing on haze pollution from the perspective of fiscal and taxation policies are limited.

Since the early 1990s, member states of the Organization for Economic Cooperation and Development (OECD) have implemented various measures to green their tax systems, aiming to protect the environment and promote sustainable development. These measures include eliminating environmentally harmful tax provisions and subsidies, adjusting distortive taxes, and introducing new environmental taxes. For instance, the European Union has encouraged member states to adopt energy and carbon taxes as part of broader environmental policies, while Japan’s “Tax for Climate Change Mitigation” illustrates how fiscal instruments can reduce greenhouse gas emissions. These policies highlight the role of the EPT in addressing environmental challenges. Studies supporting these efforts demonstrate the benefits of environmental taxes. For example, Burke [21] suggested that air pollution in the Asia–Pacific region could be mitigated through mechanisms like carbon pricing and congestion pricing. Similarly, Fotis and Polemis [22] found that the early taxation of polluting industries improves air quality, based on their survey of 34 EU countries. These findings underscore the relevance of China’s EPT policy in mitigating haze.

Before the official implementation of China’s EPT Law, some studies used pollution charges, which preceded the EPT, as proxy indicators. For example, Shi et al. [8] conducted a study in Shandong Province, China, finding that EPT could effectively improve the Air Quality Index (AQI). The enactment of the EPT Law, China’s first tax aimed at environmental protection and promoting ecological civilization, has attracted significant academic attention. Recently, studies have primarily explored the positive effects of the “fee-to-tax” reform on industrial pollution [9], environmental investment [23], and corporate performance [24], while limited attention has been given to haze pollution, closely linked to national health and urban development.

The effectiveness of the current EPT in China for mitigating air pollution remains a subject of ongoing debate. On one hand, studies suggest that EPT has the potential to regulate air pollution. Hu et al. [25] found, based on provincial-level data, that the imposition of EPT reduces emissions across various air pollutants. Using Bayesian empirical analysis, Han and Li [26] concluded that EPT can lower regional PM2.5 concentrations, with significant spatial variations. On the other hand, some scholars question the effectiveness of the current EPT in reducing emissions and controlling pollution. Li et al. [27] found that EPT's impact on air pollutants follows an "inverted U-shaped" pattern, with certain regions' EPT rates on the initial upward slope of the curve. However, most studies assess the impact of EPT on air pollution using multiple regression or predictive models, often without accounting for the endogeneity of environmental regulation, complicating accurate evaluations of the relationship between EPT and air pollution. Furthermore, there is a lack of comprehensive analysis on the EPT Law's efficacy in controlling haze pollution and exploring its underlying mechanisms.

Therefore, this study employs a quasi-natural experiment based on the implementation of the EPT Law, using annual average PM2.5 concentration data from 281 prefecture-level cities in China from 2012 to 2021 to examine the impact and mechanisms of green taxation on haze pollution. The empirical results show that the implementation of the EPT Law significantly reduces haze pollution, with this conclusion remaining robust across a series of tests. To explore the underlying mechanisms, we conduct an exploratory analysis and find that the EPT Law controls haze pollution by fostering a cleaner industrial structure, stimulating green technological innovation, and enhancing the rigidity of environmental enforcement. We further find that fiscal decentralization enhances the inhibitory effect of the EPT Law on haze pollution, and heterogeneity analysis reveals that the haze-mitigating effect is more pronounced in non-old industrial bases and cities with less pressure from officials' promotions and higher public environmental awareness.

The potential marginal contributions of this study compared to the existing literature are as follows: First, existing research on the policy effects of China's EPT Law has largely ignored its impact on haze pollution. This study empirically examines the haze-reducing effects of the EPT Law, thus broadening the scope of research on the benefits of green taxation reform. Second, unlike studies that primarily confirm the direct effects of the EPT Law on air quality, this study investigates its haze-reducing mechanisms from multiple perspectives, including cleaner industrial structures, green technological innovation, and stricter environmental law enforcement. This provides empirical evidence to clarify the mechanisms through which the EPT Law reduces haze pollution, supporting sustained efforts to achieve blue skies. Third, this study integrates the fiscal decentralization system, EPT policy, and haze pollution into a unified research framework, analyzing how fiscal decentralization influences the haze control effectiveness of the EPT Law. This opens new pathways to more effectively achieve environmentally sound governance through green taxation.

The structure of the following sections is as follows: Section 2 reviews the policy background and develops the research hypotheses, examining both the direct and indirect mechanisms through which the EPT Law impacts haze pollution. Section 3 outlines the methodology and data, providing a detailed explanation of the model settings and variable selection. Section 4 presents the empirical results. Section 5 focuses on further analyses, including tests for heterogeneity and moderating effects. Conclusions and policy implications are provided in Section 6. The overall research framework is shown in Figure 1, offering a visual summary of the study's components and flow.

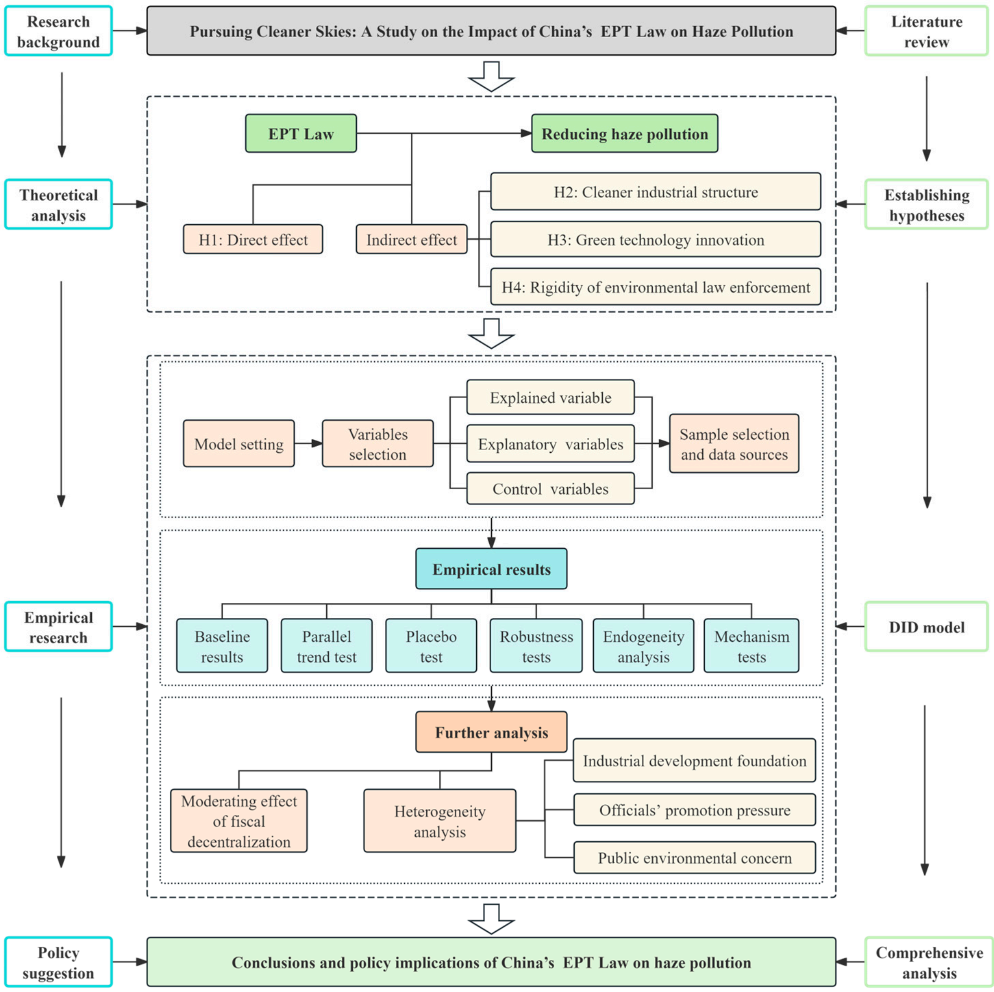

Figure 1. Research framework.

2. Policy Background, Theoretical Analysis, and Hypotheses

2.1. Policy Background

China's greening of its tax system began later than that of Western developed countries. Specifically, Western nations began evolving their tax policies to promote sustainable development in the 1950s, progressing from the initial development of green taxes to the introduction of individual environmental protection taxes and the comprehensive establishment of environmental tax systems [28]. Although China's green tax system has advanced in recent years, it still lags behind internationally due to its late start, low standards, and relative delay.

During the early stages of China's economic reform and opening up, the primary focus was on economic development and improving national living standards. Although environmental awareness began to emerge during this period, it had not yet been recognized as a core objective of national development. To address environmental pollution, China sought to use economic instruments to promote environmental protection. In 1978, China launched a pilot program for pollution charges, formally enacted in 1982. The system aimed to penalize polluters economically and subsequently reduce pollutant emissions. The pollution charge system served as a precursor to China's EPT system, laying the groundwork for the greening of its tax system.

In the 21st century, as China's economy rapidly expanded, environmental pollution became more acute, prompting the nation to integrate environmental protection into its development strategies. This integration was reflected in the refinement of the pollution charge system and the introduction of new green taxes, such as resource and consumption taxes, aimed at promoting resource conservation and environmental protection. Notable milestones include the 2007 reform of the resource tax system and the introduction of a consumption tax on luxury goods with environmental implications [29,30]. These efforts underscored China's commitment to advancing the greening of its tax system while balancing economic growth with ecological sustainability.

However, the pollution charge system, as an administrative regulation, gradually revealed challenges, including inadequate enforcement, excessive administrative intervention, and a lack of mandatory characteristics [31]. These shortcomings raised concerns about its effectiveness in reducing pollution [32]. In response to these challenges, China introduced the strategic objective of ecological civilization, emphasizing the importance of "clean waters and lush mountains". This emphasis was further reinforced in subsequent national policy frameworks aimed at expediting the reform of the ecological civilization system and creating a beautiful China.

To use tax instruments for environmental protection more effectively, China began exploring the establishment of an EPT system. After extensive preparation and research, China passed the EPT Law on 25 December 2016 and implemented it on 1 January 2018. This landmark legislation marked the transition of China's pollution charge system into taxation, signaling a new phase in the greening of China's tax system.

Recently, Chinese national policy directives have emphasized the ongoing struggle against pollution, focusing on the pursuit of blue skies, clear waters, and fertile soil. Effectively mitigating haze pollution is crucial for success in the fight for blue skies. The introduction of the EPT Law provides new strategies and tools for addressing haze pollution. By levying taxes on air pollutants emitted by enterprises, institutions, and other operators, the law directly targets the primary sources of haze pollution. In this context, haze pollution is the research focus for systematically examining the effectiveness of the EPT Law in mitigating urban haze pollution in China.

2.2. Theoretical Analysis and Hypotheses

2.2.1. Direct Governance Effect of the Implementation of the EPT Law on Haze Pollution

As a key environmental regulatory policy reflecting the principle that "Lucid waters and lush mountains are invaluable assets" [33], the implementation of the EPT Law provides new momentum for addressing haze pollution. From the enterprise perspective, the EPT Law influences through two primary avenues. First, the EPT Law grants provincial governments' autonomy in setting tax rates for atmospheric pollutant emissions, encouraging regions to raise tax rates based on their environmental capacity and governance needs, thereby increasing economic costs for enterprises to use environmental resources. These elevated costs compel enterprises to proactively seek and adopt cleaner, more efficient production models [10], reducing pollutant emissions and aiding in haze control. Second, the EPT Law introduces detailed tax relief policies, providing enterprises with a clear green transformation orientation and offering an economic "fast track" for their green development through concrete actions [34]. This stimulates enterprises' investment in environmental protection technologies, improving resource utilization efficiency and achieving energy conservation and emission reduction targets, thus laying a solid foundation for mitigating haze pollution at its source [35]. From the governmental perspective, the Law stipulates that all EPT revenue is retained by local governments, with no share for the central government [36]. This arrangement strengthens local governments' financial autonomy and resource allocation in haze control, providing substantial support for formulating and implementing precise, effective governance measures tailored to local conditions. Thus, we propose the following hypothesis:

H1. *The implementation of the EPT Law may effectively reduce haze pollution.*

2.2.2. Impact Mechanism of the Implementation of the EPT Law on Haze Pollution

This study argues that the implementation of the EPT Law effectively controls haze pollution through three main channels: promoting a cleaner industrial structure, fostering green technological innovation, and strengthening environmental law enforcement.

Promoting cleaner industrial structure. From the cost advantage perspective, based on Pigouvian tax theory [37], EPT internalizes the external costs of environmental pollution, requiring polluters to bear economic responsibility for their emissions, in line with the "polluter pays principle" [38]. This leads to differences in production cost advantages across industries. Compared to clean industries, pollution-intensive industries must pay environmental taxes based on the types and quantities of their emissions, significantly raising their production costs. Under the pressure of the environmental tax, pollution-intensive industries are forced to transform or exit the market. In contrast, clean industries benefit from cost advantages due to lower environmental burdens and gain further development opportunities through tax relief or incentives, solidifying their market positions [39]. From the resource allocation perspective, with the EPT Law's implementation and growing consumer preference for green products, clean industries face greater market demand, attracting substantial capital and labor resources from pollution-intensive industries. They integrate these resources with their advantages in environmental technologies, products, and services, optimizing resource allocation and accelerating industrial transformation towards cleaner production [40]. Additionally, industrial optimization is recognized as a key driver for environmental governance. Related research indicates that cleaner industrial adjustments not only promote the adoption of clean production methods but also enhance the overall green content of the economic system, establishing a robust foundation for the sustained reduction of haze pollution [41,42]. Therefore, we propose the following hypothesis:

H2. *The implementation of the EPT Law may reduce haze pollution through promoting cleaner industrial structure.*

Fostering green technological innovation. The implementation of the EPT Law enhances environmental regulation by raising taxation standards for taxable pollutants, effectively embodying the essence of the Porter hypothesis [43]. This hypothesis challenges the neoclassical economics view of a negative relationship between environmental regulation, corporate cost burdens, and innovation capabilities, instead emphasizing that well-designed, efficiently enforced environmental policies can act as a catalyst for green technological innovation, bridging the gap between economic growth and environmental protection to achieve "green prosperity" [44]. On the one hand, confronted with increased environmental tax burdens, enterprises shift their focus to green technological innovation, driven by the pursuit of profit maximization [45]. By innovating green production processes, enterprises adopt green energy and eco-friendly materials and implement waste recycling and reuse, which fosters the green transformation of production processes and enhances green total factor productivity [39]. Consequently, they can reduce pollution emissions, particularly from atmospheric pollutants like haze, while maintaining or expanding production scales, thus bolstering efforts to restore blue skies and white clouds [46]. On the other hand, the promulgation of the EPT Law demonstrates the government's commitment to environmental protection and clear policy direction, compelling the business community to recognize that environmental protection is critical to the long-term survival and development of enterprises. This external pressure from the government acts as a driving force that stimulates organizational vitality and innovation within enterprises [47]. It forces enterprises to abandon traditional dependencies and explore more efficient, cleaner production and pollution control pathways. This fosters the widespread application of advanced clean technologies, facilitating comprehensive haze pollution control from source to end [48]. Based on the above analysis, we propose the following hypothesis:

H3. *The implementation of the EPT Law may reduce haze pollution through facilitating green technological innovation.*

Strengthening the rigidity of environmental law enforcement. As a public good, maintaining atmospheric quality requires government intervention. Given the persistent issues in China's haze pollution control—such as lax enforcement, failure to investigate violations, and substituting fines for regulation [31], which result in a lack of government accountability—the implementation of the EPT Law marks a significant step forward toward the legalization and standardization of China's environmental governance system. This law establishes the legal foundation of a green taxation system, transcending the limitations of previous pollution discharge fee systems [49]. It stipulates the tax obligations for emissions of pollutants such as air, water, and solid waste and clarifies the legal responsibilities associated with violating these obligations at the legislative level. This transformation strengthens the accountability of local governments in environmental law enforcement, making enforcement more rigorous and creating a deterrent against illegal discharges. This compels enterprises to shift from passive compliance to actively pursuing green, environmentally friendly production pathways, ultimately reducing haze pollutants [50]. Furthermore, the EPT Law defines the regulatory responsibilities of local governments and relevant departments in environmental protection while establishing a tax-related information-sharing platform and a cooperative working mechanism [51] and enhancing the coordination and standardization of environmental law enforcement. Specifically, tax departments can conduct a more scientific and reasonable tax collection from pollutant-discharging enterprises based on emission data from environmental protection departments. Meanwhile, environmental protection departments can strengthen supervision and enforcement by utilizing the auditing capabilities of tax departments [52]. This measure optimizes the allocation of environmental regulatory resources and breaks down information silos, allowing haze control to transcend regional and departmental boundaries, fostering synergy and promoting improvements in atmospheric quality [53]. In light of this, we propose the following hypothesis:

H4. *The implementation of the EPT Law may reduce haze pollution through strengthening the rigidity of environmental law enforcement.*

According to the above analysis, Figure 2 illustrates the influence mechanism between the EPT Law and haze pollution, highlighting both direct and indirect pathways for reducing haze levels.

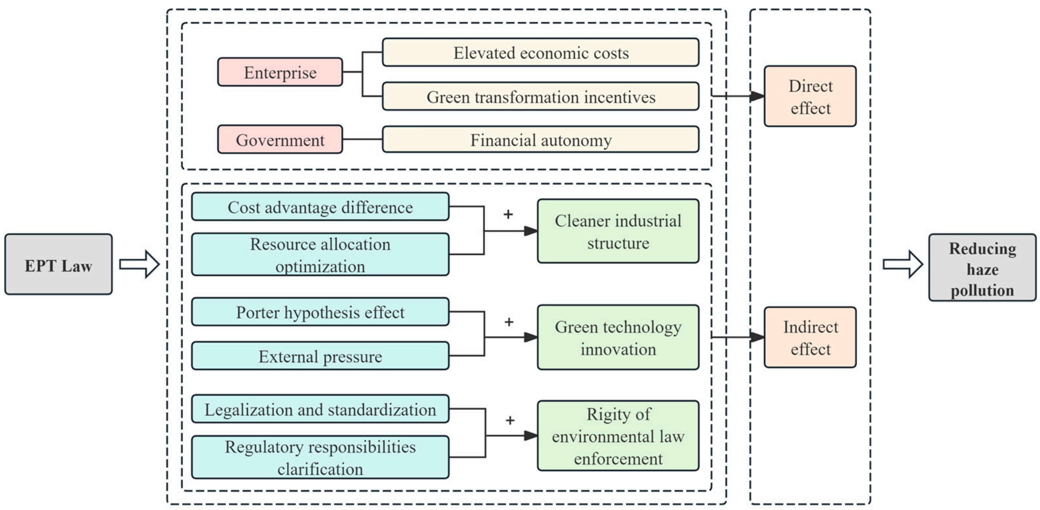

Figure 2. Influence mechanism.

3. Method

3.1. Model Setting

The EPT builds upon the existing pollutant discharge fee system, allowing local governments to adjust tax rates for taxable pollutants within statutory limits based on regional environmental, economic, and social factors. Following the EPT Law's implementation on 1 January 2018, some regions raised tax rates above the original pollutant discharge fee, while others retained the original rates under a tax-neutral approach. This variation constitutes a natural experiment in economics. To examine the EPT Law's impact on haze pollution, a Difference-in-Differences (DID) model was employed, leveraging prefecture-level city data for causal identification [54]. The model evaluates differences across two dimensions: time (before and after the EPT Law's implementation) and regions (areas with higher tax burdens versus tax-neutral regions). The specific model is specified as follows:

$$\mathrm{lnpm2.5}_{i,t} = \beta_0 + \beta_1 \mathrm{Reform}_i \times \mathrm{Post}_t + \beta_2 \mathrm{Controls}_{i,t} + \theta_i + \delta_t + \varepsilon_{i,t}, \quad (1)$$

where $\mathrm{lnpm2.5}_{i,t}$ denotes haze pollution in city i during year t, and $\mathrm{Reform}_i \times \mathrm{Post}_t$ serves as the core explanatory variable, signifying the interaction term between the regional dummy variable and the time dummy variable. Its coefficient reflects the impact of the EPT Law implementation on urban haze pollution between regions with increased pollutant tax burdens and those with tax burden neutrality. $\mathrm{Controls}_{i,t}$ represents a series of control variables. θ_i and δ_t denote city fixed-effects and time fixed-effects, respectively. $\varepsilon_{i,t}$ represents the random disturbance term, and the standard errors are clustered at the city level.

3.2. Variable Selection

3.2.1. The Explained Variable

Haze pollution (lnpm2.5) is used as the explained variable, measured as the logarithm of the annual average PM2.5 surface concentration, a primary contributor to haze pollution [55]. Specifically, the PM2.5 data are sourced from the Atmospheric Composition Analysis Group at Washington University in St. Louis, with city-level haze data extracted using the zonal statistics tool in ArcGIS 10.8.

3.2.2. Explanatory Variables

The explanatory variables include the regional dummy variable Reform, representing the adjustment of tax burden standards for taxable pollutants, and the temporal dummy variable Post, indicating the official implementation of the EPT Law. For the variable Reform, based on documents outlining adjustments to local EPT collection standards, regions with increased tax burdens include Beijing, Hebei, Shanxi, Jiangsu, Shandong, Henan, Hunan, Guangxi, Hainan, Chongqing, Sichuan, and Guizhou, totaling 12 provinces. Cities within these regions are assigned a value of 1 for Reform, while those in regions with unchanged tax burdens are assigned a value of 0. For the variable Post, a value of 0 is assigned for years before 2018, and a value of 1 is assigned for 2018 and beyond. The interaction term, Reform × Post, derived from multiplying the regional and temporal dummy variables, serves as the primary explanatory variable in this study.

3.2.3. Control Variables

Based on existing research [20,56,57], this study incorporates a set of urban characteristic control variables that influence haze pollution into the empirical model. These include Economic Development (lnEco), measured by the logarithm of per capita GDP; Population Density (lnPop), measured by the logarithm of urban population per unit area; Financial Development (Finance), represented by the ratio of year-end institutional deposit and loan balances to GDP; Openness (Open), measured by the ratio of total import and export value to regional GDP; Urban Greening (Green), assessed by the green coverage rate of built-up areas; Transportation Infrastructure (lnRoad), measured by the logarithm of road area per capita; and Internet Development (lnInternet), measured by the logarithm of the number of internet access points per hundred people. The descriptive statistics of the key variables in this study are presented in Table 1.

Table 1. Descriptive statistics of main variables.

Variables	Sample	Mean	Standard Deviation	Min	Max
lnpm2.5	2810	3.6918	0.3776	2.3336	4.6606
Reform	2810	0.4306	0.4952	0.0000	1.0000
Post	2810	0.4000	0.4900	0.0000	1.0000
Reform × Post	2810	0.1722	0.3777	0.0000	1.0000
lnEco	2810	10.7886	0.5601	9.0066	13.0557
lnPop	2810	5.7346	0.9883	1.7393	9.0886
Finance	2810	2.5837	1.2322	0.6354	21.3018
Open	2810	0.1718	0.2748	0.0003	2.4913
Green	2810	0.4045	0.0696	0.0097	1.5811
lnRoad	2810	2.8310	0.4283	0.8109	4.0955
lnInternet	2810	3.0809	0.5769	0.8480	4.8352

3.3. Sample Selection and Data Sources

To ensure data availability and consistency, this study selects 281 prefecture-level cities from 2012 to 2021 as the sample. The year 2012 is selected as the starting point because it marks the first inclusion of PM2.5 as a monitoring indicator in the Ambient Air Quality Standards issued by China's Ministry of Ecology and Environment. Additionally, haze prevention and control began to be gradually incorporated into local government work reports, making 2012 a logical starting point for this study. The PM2.5 data in this study are sourced from the Atmospheric Composition Analysis Group (ACAG), while control variables and other data are obtained from sources such as the China City Statistical Yearbook, EPS Database, China National Research Data Service Platform (CNRDS), and Peking University Law Database. Missing data are manually collected from local statistical bulletins or replaced using interpolation methods.

4. Empirical Results and Analysis

4.1. Benchmark Regression Results

Table 2 presents the benchmark regression results on how the EPT Law affects haze pollution levels. Column (1) presents the regression results based on Model (1), which includes only the core explanatory variable Reform × Post. The coefficient of Reform × Post is significantly negative at the 1% level. Columns (2) to (4) present the regression results after sequentially adding control variables, city, and time fixed-effects to Column (1). The coefficient of Reform × Post remains significantly negative, indicating that the implementation of the EPT Law reduces urban PM2.5 concentrations and effectively mitigates haze pollution. According to the results in Column (4), the coefficient of Reform × Post is −0.0353, statistically significant at the 1% level. This suggests that, compared to regions with tax burden parity, the EPT Law reduces haze pollution levels by approximately 0.0353 units in regions with increased tax burdens. H1 is thus confirmed.

The regression coefficients of the control variables in Column (4) of Table 2 show that economic development, population density, and financial and internet development all have a significant inhibitory effect on urban haze pollution. This finding aligns with expectations as economically developed regions typically have greater resources to invest in environmental governance. An increase in population density may lead to the relocation of heavy polluters, alleviating the pollution burden within cities. Financial development provides support for environmental protection technologies and green industries, while internet development enhances public awareness and promotes environmental protection actions.

Table 2. Benchmark regression results.

	(1)	(2)	(3)	(4)
Reform × Post	−0.0816 *** (0.0253)	−0.0499 * (0.0255)	−0.1425 *** (0.0115)	−0.0353 *** (0.0116)
lnEco		0.1950 *** (0.0230)	−0.2685 *** (0.0900)	−0.1982 *** (0.0623)
lnPop		0.0559 (0.0348)	−0.2486 *** (0.0352)	−0.1146 *** (0.0260)
Finance		−0.0196 (0.0157)	−0.0547 *** (0.0170)	−0.0107 ** (0.0050)
Open		−0.3318 *** (0.0675)	0.0307 (0.0725)	0.0411 (0.0484)
Green		−0.0761 (0.1429)	−0.2349 *** (0.0818)	−0.0489 (0.0614)
lnRoad		0.0505 * (0.0294)	−0.0481 *** (0.0182)	0.0290 * (0.0153)
lnInternet		−0.2602 *** (0.0282)	−0.1374 *** (0.0224)	−0.0386 ** (0.0165)
_cons	3.7058 *** (0.0197)	2.7769 *** (0.3245)	8.7288 *** (0.6078)	6.1483 *** (0.4613)
CE	NO	NO	YES	YES
TE	NO	NO	NO	YES
N	2810	2810	2810	2810
adj. R^2	0.0063	0.3370	0.8189	0.8875

Note: The values in parentheses represent city-level clustered standard errors. The explained variable is lnpm2.5. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. CE and TE refer to city and time fixed-effects, respectively. The same as below.

Contrary to expectations, the advancement of transportation infrastructure has not mitigated haze pollution but rather exacerbated it. This may be due to the fact that expanding transportation infrastructure often relies excessively on increasing road and vehicle numbers, aggravating traffic congestion and emissions. Additionally, some transportation infrastructure projects may overlook environmental impact assessments, leading to adverse environmental effects during construction and operation.

4.2. Parallel Trend Test

The premise of using the DID model is to satisfy the parallel trend assumption, which posits that, prior to the official implementation of the EPT Law, haze pollution levels in both the treatment and control groups exhibit a consistent trend. Based on Liu et al. [58], an econometric model is established in this study as follows:

$$\mathrm{lnpm2.5}_{i,t} = \alpha + \sum\nolimits_{n \geq -3}^{3} \beta_n D_{i,t_0+n} + \gamma \mathrm{Controls}_{i,t} + \theta_i + \delta_t + \varepsilon_{i,t}, \quad (2)$$

where D_{i,t_0+n} represents the dummy variable for the year of implementation of the EPT Law. When $n < 0$, it signifies the pre-implementation period of the policy; when $n = 0$, it represents the current period of policy implementation; and when $n > 0$, it indicates the post-implementation period. This study utilizes the period immediately preceding the policy implementation as the base period to analyze the dynamic trend changes in cities before and after its enforcement.

As shown in Figure 3, prior to the implementation of the EPT Law, the coefficient estimates are insignificant and fluctuate around the 0 baseline, indicating no significant systematic differences or pre-existing trends in haze pollution between the treatment and control groups, thus satisfying the parallel trend assumption. Furthermore, the figure shows that after the implementation of the EPT Law, the coefficient estimates are significantly negative at the 5% significance level, showing a clear downward trend. This suggests that the haze pollution problem in the treatment group has been effectively mitigated compared to the control group, further confirming the robustness of the benchmark regression results.

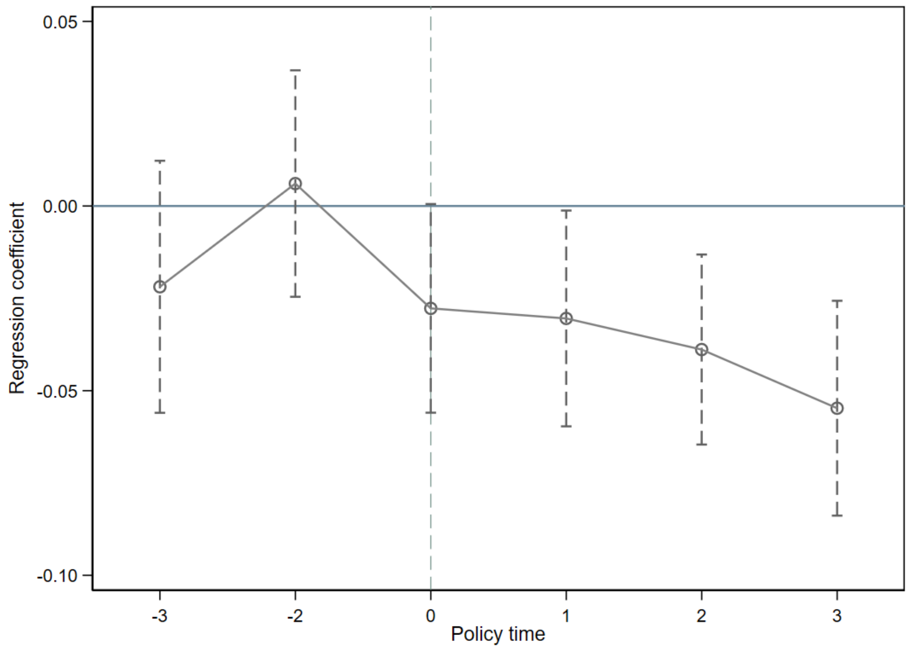

Figure 3. Parallel trend test.

4.3. Placebo Test

Despite controlling for both city and time fixed-effects in the benchmark regression, unobservable city-specific factors may still impact the research findings. To address this issue, following La Ferrara et al. [59], this study employs a placebo test by randomly generating samples for the treatment group. Specifically, the explanatory variable Reform $\times$ Post is randomly reassigned to construct a "pseudo-policy dummy variable", and the process is repeated 500 times for regression analysis using Model (1). The resulting observations are shown in Figure 4. It is evident that the randomly generated, erroneous coefficient estimates are mostly clustered around 0 and are statistically insignificant, sharply contrasting with the actual benchmark regression coefficient estimate of -0.0353. This finding suggests that unobservable factors do not exert a significant influence on the policy effects, further enhancing the robustness of the results.

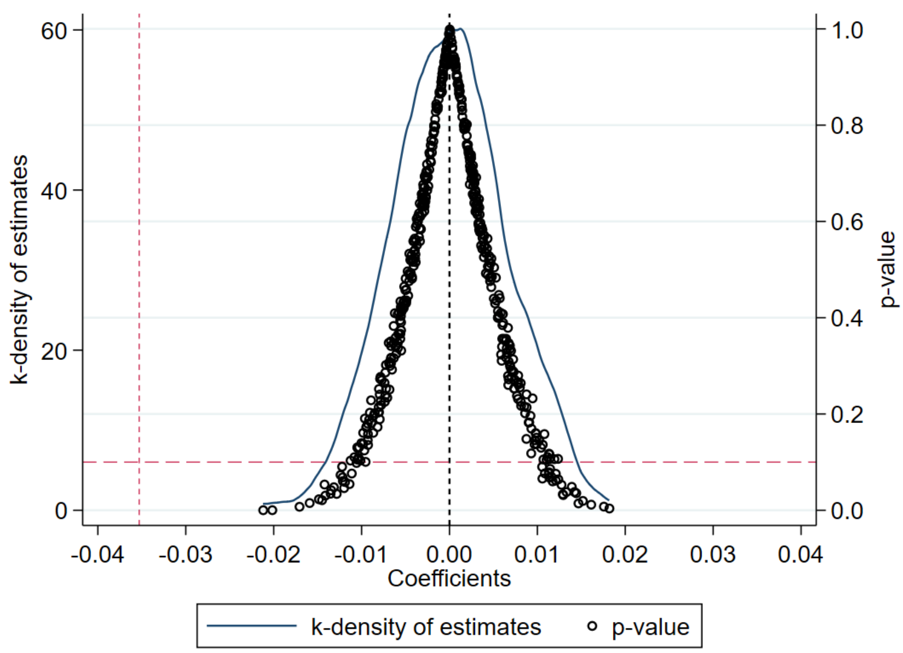

Figure 4. Placebo test.

4.4. Robustness Tests

4.4.1. Addressing Sample Selection Bias

Prior to the implementation of the EPT Law, observable variables across cities may exhibit significant differences, making it challenging to guarantee the randomness of assigning experimental and control groups based solely on whether the tax burden increased. As a result, the DID estimation results may be affected by sample selection bias. To address this issue, this study employs two verification methods.

Propensity Score Matching (PSM). Following Duan and Rahbarimanesh [60], this study selects control variables such as urban population density and economic development as covariates. A 1:1 nearest neighbor matching method without replacement is applied each year to match samples. After excluding a small number of unmatched samples, regression analysis is re-conducted based on Model (1), and the results are presented in Column (1) of Table 3. The results indicate that the Reform × Post coefficient remains significantly negative, consistent with the benchmark regression.

Table 3. Addressing sample selection bias.

	(1)	(2)
Reform × Post	−0.0297 **	−0.0296 **
	(0.0125)	(0.0117)
_cons	6.1799 ***	6.2645 ***
	(0.4861)	(0.4437)
Controls	YES	YES
CE	YES	YES
TE	YES	YES
N	2490	2810
adj. R^2	0.8670	0.9071

Entropy Balancing Method (EBM). Referring to Madsen and McMullin [61], this study adopts the entropy balancing method, which preserves sample size, to minimize differences between the treatment and control groups across various covariates. Regression analysis is then re-executed, and the results are shown in Column (2) of Table 3. The results show that the Reform × Post coefficient remains significantly negative, indicating that the original model is not significantly affected by sample selection bias.

4.4.2. Excluding the Interference of Other Policies

To mitigate the potentially confounding effects of other policies during the sample period on the benchmark regression results, this study seeks to eliminate their impacts. Specifically, policies that may affect the benchmark regression outcomes are divided into two groups: environmental protection policies and tax reform policies. The former include the "Ten Measures for Air" (Airten) and Ecological Compensation policies (Ecocomp), while the latter consist of tax incentives related to the "Replacing Business Tax with Value Added Tax" (VAT) and tax regulatory policies from the third phase of the Golden Tax Project (GTP). Based on Yuan et al. (2023) [62], we incorporate dummy variables Airten, Ecocomp, VAT, and GTP into the benchmark regression model to control for their impacts on the haze reduction effect of the EPT Law. When the city has implemented the Airten (Ecocomp; VAT; GTP) policy, the dummy variable Airten (Ecocomp; VAT; GTP) is assigned a value of 1; otherwise, it is assigned a value of 0. According to Columns (1) to (5) of Table 4, the coefficient of the core explanatory variable remains significantly negative, indicating that neither environmental protection policies nor tax reform policies during the sample period significantly influence the benchmark regression results.

Table 4. Excluding the interference of other policies.

	(1)	(2)	(3)	(4)	(5)
Reform × Post	−0.0352 ***	−0.0356 ***	−0.0374 ***	−0.0441 ***	−0.0466 ***
	(0.0116)	(0.0116)	(0.0116)	(0.0115)	(0.0115)
Airten	−0.0365 **				−0.0440 **
	(0.0179)				(0.0190)
Ecocomp		−0.0246 **			−0.0317 ***
		(0.0120)			(0.0120)
VAT			0.0401 ***		0.0365 ***
			(0.0134)		(0.0138)
GTP				−0.0589 ***	−0.0617 ***
				(0.0174)	(0.0174)
_cons	6.1226 ***	6.1171 ***	6.1040 ***	6.0854 ***	5.9709 ***
	(0.4553)	(0.4579)	(0.4546)	(0.4590)	(0.4416)
Controls	YES	YES	YES	YES	YES
CE	YES	YES	YES	YES	YES
TE	YES	YES	YES	YES	YES
N	2810	2810	2810	2810	2810
adj. R^2	0.8876	0.8877	0.8877	0.8883	0.8889

4.4.3. Accounting for Potential Omitted Variables

To address potential biases from omitted variables in the benchmark regression results, this study examines the influence of local climatic conditions on urban haze pollution levels [63]. The annual average wind speed (lnWind), precipitation (lnRain), and temperature (lnTemp) of the sample cities are added as additional control variables to the benchmark regression model. These meteorological data originate from the National Centers for Environmental Information (NCEI) and the National Oceanic and Atmospheric Administration (NOAA) of the United States. As shown in Columns (1) to (4) of Table 5, the coefficient of Reform × Post remains significantly negative, indicating that the omitted meteorological variables do not alter the benchmark regression results, affirming the robustness of the findings.

Table 5. Accounting for potential omitted variables.

	(1)	(2)	(3)	(4)
Reform × Post	−0.0371 ***	−0.0335 ***	−0.0309 ***	−0.0304 **
	(0.0117)	(0.0117)	(0.0116)	(0.0118)
lnwind	0.0499			0.0243
	(0.0559)			(0.0540)
lnrain		−0.0588 *		−0.0517 *
		(0.0302)		(0.0303)
lntemp			0.2717 ***	0.2567 ***
			(0.0950)	(0.0888)
_cons	6.0329 ***	6.5915 ***	5.0272 ***	5.4192 ***
	(0.4647)	(0.4887)	(0.5468)	(0.5821)
Controls	YES	YES	YES	YES
CE	YES	YES	YES	YES
TE	YES	YES	YES	YES
N	2810	2810	2805	2805
adj. R^2	0.8884	0.8875	0.8902	0.8909

4.4.4. Changing the Measurement of the Explained Variable

Among the pollutants contributing to haze formation, gaseous pollutants constitute a notable portion alongside particulate pollutants [64]. Based on Ai et al. [65], the logarithm of SO2 emissions (lnSO2) is used as a proxy variable for haze pollution. Data are sourced from the China Urban Statistical Yearbook (2013–2022). As shown in Column (1) of Table 6, the coefficient of Reform × Post remains significantly negative.

Table 6. Robustness test.

	(1)	(2)	(3)
Reform × Post	−0.2532 ***	−0.0353 ***	−0.0353 *
	(0.0643)	(0.0094)	(0.0201)
_cons	9.7706 ***	6.1483 ***	6.1483 ***
	(1.9602)	(0.3769)	(0.6264)
Controls	YES	YES	YES
CE	YES	YES	YES
TE	YES	YES	YES
Clustering level	city	city × year	province × year
N	2134	2810	2810
adj. R^2	0.8759	0.8875	0.8875

Note: The explained variable in Column (1) is lnSO2. Robust standard errors are clustered at the city × year and province × year level in Columns (2) and (3), respectively.

4.4.5. Modifying the Clustering Level

In the benchmark regression analysis, standard errors are adjusted for clustering at the city level. To further verify the robustness of the empirical results, this study adjusts the clustering level of standard errors to city × year and province × year, allowing for observation of any changes in the findings. As shown in Columns (2) and (3) of Table 3, the coefficient of Reform × Post remains significantly negative, consistent with the benchmark regression results.

4.5. Endogeneity Analysis

Given that the decision to increase EPT rates among cities is not entirely random, following Xu et al. [66], this study uses city relief degree as an instrumental variable to address endogeneity concerns in the regression model. Relief degree is selected because it is a pivotal factor influencing urban construction, which leads to pollution emissions and affects the formulation of EPT standards in different regions. This meets the relevance requirement for instrumental variables. Additionally, relief degree is determined by the city's inherent geographical conditions, possesses natural exogeneity, and does not directly influence haze pollution from economic activities, satisfying the exogeneity requirement. Since city relief degree is cross-sectional data that remains constant over time, this study introduces an interaction term between it and annual dummy variables as the instrumental variable (IV) in the regression model.

In the first-stage regression, as shown in Column (1) of Table 7, the coefficient of the instrumental variable is significant at the 1% level, indicating a strong correlation between the IV and Reform × Post. In the second-stage regression, as shown in Column (2), the Kleibergen–Paap rk LM statistic is significant at the 1% level, rejecting the null hypothesis of underidentification for the instrumental variable. The Cragg–Donald Wald F statistic exceeds the Stock–Yogo critical value for weak instrumental variable identification at the 10% level, rejecting the weak IV hypothesis. Collectively, these tests validate the IV. The second-stage regression results show that the coefficient of the core explanatory variable Reform × Post is significantly negative at the 5% level, confirming the robustness of the benchmark regression results after addressing endogeneity issues.

4.6. Mechanism Tests

Previous sections have shown that the implementation of the EPT Law reduces urban PM2.5 concentrations and effectively controls haze pollution, but the underlying mechanisms of this effect remain unverified. Based on the earlier theoretical analysis, this study tests whether the EPT Law impacts haze reduction through three mechanisms: cleaner industrial structure, green technological innovation, and strengthened environmental law enforcement by constructing the following model:

$$M_{i,t} = \alpha_0 + \alpha_1 \mathrm{Reform}_i \times \mathrm{Post}_t + \alpha_2 \mathrm{Controls}_{i,t} + \theta_i + \delta_t + \varepsilon_{i,t}, \quad (3)$$

where $M_{i,t}$ represents the mechanism variables, encompassing cleaner industrial structure (ISC), green technological innovation (GTI), and strengthened environmental law enforcement rigidity (lnLaw). The remaining variables are the same as in Model (1).

Table 7. Endogeneity test.

	(1) First Stage	(2) Second Stage
Reform × Post		−0.3831 ** (0.1827)
IV	−0.0171 *** (0.0054)	
Controls	YES	YES
CE	YES	YES
FE	YES	YES
Kleibergen–Paap rk LM statistic		8.929 ***
Cragg–Donald Wald F statistic		62.323 [16.38]
N	2810	2810

Note: The values within the brackets [ ] represent the 10% critical values for the Stock–Yogo weak instrumental variable test.

4.6.1. Cleaner Industrial Structure

The implementation of the EPT Law establishes an economic incentive mechanism of "pay more for more emissions, pay less for less emissions, and pay nothing for no emissions", causing pollution-intensive enterprises to be gradually marginalized and eventually exit the market. Meanwhile, environmentally oriented enterprises, such as knowledge-intensive and technology-intensive ones, seize opportunities to acquire production factor resources, alleviating imbalances in factor allocation and facilitating the transition to a cleaner industrial structure. Existing research widely recognizes industrial structure as a key factor influencing haze pollution. Zhang et al. [67] suggest that "green adjustments" to industrial structure mitigate pollutants emitted during production by reducing the proportion of high-pollution, high-energy-consuming industries, thereby reducing haze sources and easing environmental pressure.

To test whether the EPT Law reduces urban haze pollution by promoting a cleaner industrial structure, this study, following Xie and Teo [68], approximates the tertiary industry as a clean sector. The degree of cleaner industrial structure (ISC) is measured as the proportion of local tertiary industry added value to GDP. The results in Column (1) of Table 8 show that the coefficient of Reform × Post is significantly positive, indicating that the EPT Law promotes the transition to a cleaner industrial structure, effectively reducing urban haze pollution. Hence, H2 is confirmed.

Table 8. Mechanism tests.

	(1) ISC	(3) GTI	(2) lnLaw
Reform × Post	0.0116 ** (0.0053)	0.0566 *** (0.0200)	0.6136 *** (0.1333)
_cons	1.0000 *** (0.1635)	0.1599 (0.7165)	1.7317 (4.1408)
Controls	YES	YES	YES
CE	YES	YES	YES
TE	YES	YES	YES
N	2810	2810	2810
adj. R^2	0.8987	0.2400	0.7744

Note: The explained variables in Columns (1) to (3) are ISC, GTI, and lnLaw respectively.

4.6.2. Green Technological Innovation

The implementation of the EPT Law has tightened environmental regulations, with some regions raising collection standards for taxable pollutants, potentially compelling enterprises to pursue green technological innovation, thereby realizing the Porter hypothesis. Existing research widely recognizes that green technological innovation can effectively reduce haze pollution. In terms of the front-end prevention of haze pollution, Liu et al. [69] argue that researching and applying green production technologies helps enterprises reduce reliance on traditional production pathways, significantly boosting green productivity and effectively controlling atmospheric pollution emissions. For end-of-pipe treatment, Liu et al. [57] note that advanced atmospheric treatment, waste disposal, and ecological restoration technologies efficiently treat already formed pollutants, inhibiting the formation and diffusion of haze pollution.

To test whether the EPT Law reduces urban haze pollution by promoting green technological innovation, this study, following Weng et al. [70], uses the ratio of green patent grants to current green patent applications as a proxy for urban green technological innovation (GTI). The results in Column (2) of Table 8 show that the coefficient of Reform × Post is significantly positive, indicating that the EPT Law has enhanced green technological innovation and verified the Porter hypothesis. Higher green technological innovation facilitates urban haze pollution treatment, confirming H3.

4.6.3. Strengthened Rigidity in Environmental Law Enforcement

The implementation of the EPT Law transitions environmental protection from administrative and economic measures to legal means, accelerating the legalization of environmental protection in China and providing clearer and stronger legal safeguards. Strengthening environmental law enforcement and penalizing enterprises for illegal activities are crucial measures to address challenges in haze prevention and control. The existing literature widely recognizes that the rigidity of law enforcement is a key factor in the pollution reduction effectiveness of environmental regulations. Van Rooij [71] states that increasing the intensity of regional environmental law enforcement raises the likelihood of pollution detection and punishment costs for enterprises, thereby curbing pollution discharge behavior and achieving environmental governance.

To test whether the EPT Law reduces urban haze pollution by strengthening environmental law enforcement, this study, following Liu et al. [72], uses the logarithm of environmental penalty cases at the prefecture level as a proxy for enforcement rigidity (lnLaw). The results in Column (3) of Table 8 show that the coefficient of Reform × Post is significantly positive, indicating that the EPT Law has enhanced local environmental law enforcement, supporting efforts to prevent and control haze pollution. Hence, H4 is confirmed.

5. Further Analysis

5.1. Analysis of the Moderating Effect of Fiscal Decentralization

The implementation of the EPT Law is considered an institutional outcome of China's innovation in environmental policy and the reconstruction of environmental partnerships. Its effectiveness depends on the scientific design of the taxation system, autonomous exercise of tax powers, and environmental optimization of tax policies. China's environmental tax law incorporates the principles of statutory taxation and local autonomy, granting substantial autonomy in tax collection and administration, as well as full discretion over revenue allocation to local governments [73]. This aims to stimulate enthusiasm and innovation in local environmental governance. However, in the context of complex fiscal decentralization, two key questions arise: Can the fiscal decentralization system align with the goal of effective environmental governance? Does this institutional arrangement moderate the haze reduction effectiveness of the EPT Law?

First, local governments may shift spending priorities to areas that significantly stimulate economic growth, reducing the scale of environmental protection expenditures. This can result in "race to the bottom" and "free-riding" phenomena in environmental governance [74], ultimately undermining the haze reduction effectiveness of the EPT Law. Second, compared to the central government, local governments possess informational advantages regarding local economic development and environmental governance, with a better understanding of the expected policy effects of market-based environmental regulations like EPT. Consequently, tax rates for taxable pollutants can be adjusted to align with local development preferences, enabling tailored policies across regions. A higher degree of fiscal decentralization provides local governments with more financial reserves for haze governance and allows for regionally tailored fund expenditures, enhancing the haze reduction effect of the EPT Law. The mechanism of this moderating effect is shown in Figure 5.

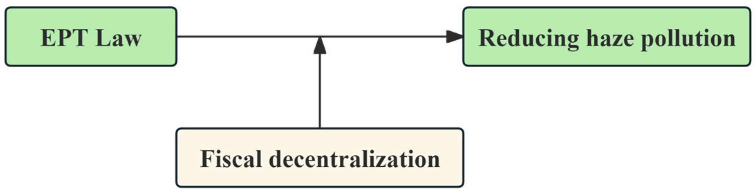

Figure 5. The mechanism of the moderating effect.

To verify the moderating effect of fiscal decentralization, this study adopts the ratio of local general public budget revenue to central government general public budget revenue as a metric for measuring fiscal decentralization (FD), following Elheddad et al. [75]. Additionally, the ratio of local general public budget expenditure to central government general public budget expenditure serves as a robustness check indicator for fiscal decentralization. Based on Model (1), the following model is constructed:

$$\text{lnpm2.5}_{i,t} = \varphi_0 + \varphi_1 \text{FD}_{i,t} \times \text{Reform}_i \times \text{Post}_t + \varphi_2 \text{Reform}_i \times \text{Post}_t + \varphi_3 \text{FD}_{i,t} + \varphi_4 \text{Controls}_{i,t} + \theta_i + \delta_t + \varepsilon_{i,t}, \quad (4)$$

where $\text{FD}_{i,t}$ represents the degree of fiscal decentralization, and $\text{FD}_{i,t} \times \text{Reform}_i \times \text{Post}_t$ is the interaction term between the moderating variable (FD) and the core explanatory variable (Reform × Post), both centered, with the remaining variables being the same as in Model (1).

The results in Table 9 reveal that the coefficients of the interaction terms between fiscal revenue decentralization (FRD) and fiscal expenditure decentralization (FED) with the core explanatory variable are both significantly negative. These findings suggest that fiscal decentralization enhances the inhibitory effect of the EPT Law on haze pollution. By allowing local governments to adapt the intensity of environmental regulations and subsidy standards to regional needs, fiscal decentralization promotes local enterprises' enthusiasm for green technological innovation. For example, fiscal decentralization enabled Guangdong Province to pilot emissions trading systems that align with regional industrial characteristics, fostering improved environmental performance. These mechanisms illustrate how fiscal decentralization can facilitate effective haze pollution governance by aligning national policies with local priorities.

5.2. Heterogeneity Analysis

While previous sections thoroughly examined the impact and mechanism of the EPT Law on urban haze pollution, they focused on the overall level without addressing the heterogeneity of its impact across different contexts. Therefore, this section further conducts heterogeneity tests on three aspects: the city's industrial development foundation, officials' promotion pressure, and public environmental concern.

Table 9. Moderating effect of fiscal decentralization.

	(1) FRD	(2) FED
FD × Reform × Post	−1.5856 ** (0.6201)	−0.6664 *** (0.1804)
Reform × Post	−0.0324 *** (0.0115)	−0.0317 *** (0.0114)
FD	−11.9359 ** (4.8005)	−4.7233 *** (1.7877)
_cons	5.9423 *** (0.4457)	5.8718 *** (0.4449)
Controls	YES	YES
CE	YES	YES
TE	YES	YES
N	2810	2810
adj. R^2	0.8883	0.8886

5.2.1. Industrial Development Foundation

Industrial production reliant on traditional energy sources is a significant cause of haze pollution [76]. The diverse industrial development foundations of cities may lead to varying progress in industrial structural transformation, affecting the effectiveness of the haze reduction benefits of the EPT Law. To examine the heterogeneous impact of industrial development on the haze reduction effect of the EPT Law, this study divides the sample cities into 92 old industrial base cities and 189 non-old industrial base cities, based on the "National Plan for the Adjustment and Transformation of Old Industrial Bases (2013–2022)", and conducts grouped regressions.

According to the results in Columns (1) and (2) of Table 10, the EPT Law has significantly reduced haze pollution in non-old industrial base cities while it has had little effect in old industrial base cities. The plausible explanation is that old industrial base cities often rely on heavy industries, with a homogeneous economic structure and high energy consumption. Additionally, a lag in environmental protection technologies may lead to a stalemate in high-input, high-emission economic development paths. In response to increased environmental tax burdens, industrial enterprises opt to bear higher pollution taxes rather than change traditional production modes, hindering the clean transformation of industrial structure in the short term and impeding haze pollution control.

Table 10. Heterogeneity analysis.

	(1) Old	(2) Non-Old	(3) High OPP	(4) Low OPP	(5) High PEC	(6) Low PEC
Reform × Post	−0.0248 (0.0208)	−0.0400 *** (0.0136)	−0.0330 * (0.0168)	−0.0183 (0.0152)	−0.0430 *** (0.0157)	−0.0258 (0.0189)
_cons	5.9612 *** (0.8508)	5.9374 *** (0.5381)	5.6999 *** (0.5524)	6.4974 *** (0.6713)	6.2538 *** (0.6420)	6.1412 *** (0.7206)
Controls	YES	YES	YES	YES	YES	YES
CE	YES	YES	YES	YES	YES	YES
TE	YES	YES	YES	YES	YES	YES
N	920	1890	1394	1416	1404	1406
adj. R^2	0.8575	0.8997	0.8943	0.8841	0.8884	0.8875

5.2.2. Officials' Promotion Pressure

Local government competition stems from China's decentralization system. To achieve performance evaluation targets, government officials have created a tournament-like system linking regional economic growth to their promotions. Local officials face dilemmas related to environmental opportunism under promotion pressure, which may influence the effectiveness of haze governance through the EPT Law. Therefore, following Tang et al. [77], this study analyzes the differences in the haze reduction effect of the EPT Law based on officials' promotion pressure (OPP). If a city's GDP growth rate is lower than the weighted average of its province for that year, it is classified as a high-OPP sample group; otherwise, as a low-OPP sample group.

According to the results in Columns (3) and (4) of Table 10, the EPT Law significantly improves urban air quality in areas with lower officials' promotion pressure but has no significant effect in areas with higher promotion pressure. The plausible reason is that local officials who have an advantage in the tournament system stop blindly pursuing economic growth, opting to tighten environmental regulatory standards, enhance the enforcement rigidity of the EPT Law, and foster a green and high-quality development model, better fulfilling the original goal of pollution control through the policy of converting environmental protection fees into taxes. In areas with higher officials' promotion pressure, local governments may reduce the environmental tax burden to compete for production factors, seeking promotion capital, which leads to the concentration of pollution-intensive industries and makes it difficult for the EPT Law to reduce haze pollution.

5.2.3. Public Environmental Concern

Given China's commitment to building a modern environmental governance system involving multiple parties, the effectiveness of the EPT Law cannot be achieved without the combined efforts of governments, enterprises, and the public. Public supervision plays a constraining role as informal environmental regulation, compelling enterprises to regulate their pollution discharge behavior and adding momentum to haze governance efforts.

To test the heterogeneous impact of public environmental concern on the haze reduction effect of the EPT Law, this study, following Ren and Ren [78], uses the Baidu haze search index to measure public environmental concern and divides the sample into two groups based on the median of the city's province in the current year: high and low public environmental concern (PEC) groups for grouped regressions. According to the results in Columns (5) and (6) of Table 10, in areas with higher public environmental concern, the EPT Law has had a significant haze reduction effect, while no significant effect was observed in regions with lower public concern. The possible reason is that under the dual pressure of increased environmental tax burdens and heightened public awareness, high-pollution enterprises face higher public "anger costs", stimulating their enthusiasm for energy conservation and emission reduction through measures like green technological innovation and increased environmental investment, thus improving their environmental performance and contributing to regional haze governance.

6. Conclusions and Policy Implications

Using panel data from 281 prefecture-level cities spanning 2012 to 2021, this study treats the official implementation of the EPT Law as a quasi-natural experiment and applies a DID model to explore the impact and mechanisms of greening the tax system on haze pollution.

First, our study shows that the implementation of the EPT Law significantly reduces urban PM2.5 concentrations, effectively mitigating haze pollution. This finding contributes to a deeper understanding of how market-based environmental policies can improve air quality. By demonstrating the tangible outcomes of the EPT Law, our research provides empirical support for the potential of regulatory frameworks in addressing pressing environmental challenges.

Second, we clarify the mechanisms through which the EPT Law achieves its haze-reduction effect. Specifically, the law promotes a cleaner industrial structure by optimizing resource allocation, fosters green technological innovation by creating a market for emission-reduction technologies, and strengthens environmental law enforcement by establishing clear, enforceable emission limits. These mechanisms collectively contribute to a substantial reduction in haze pollution, highlighting the multifaceted benefits of the EPT Law.

Third, our analysis shows that fiscal decentralization enhances the haze-reduction effect of the EPT Law. By granting local governments greater autonomy in resource allocation and policy implementation, fiscal decentralization enables more tailored and effective responses to local environmental challenges. This finding highlights the importance of considering institutional factors when assessing the impact of environmental policies.

Fourth, we identify contextual factors that influence the effectiveness of the EPT Law in haze pollution control. In cities that are non-old industrial bases, where officials face less promotion pressure and public environmental concern is higher, the EPT Law yields more significant results. These findings suggest that the success of environmental policies depends on a range of social, economic, and political factors and that policymakers should consider these factors when designing and implementing regulatory frameworks.

Based on these conclusions, the following key policy implications are drawn:

(1) Refine the green tax system. It is essential to improve the green tax system continuously, ensuring that legislation precedes the introduction of new taxes. The success of the EPT Law underscores the importance of legally establishing green taxes with strong authority to combat haze pollution and support the Blue Sky Protection Campaign.

(2) Optimize fiscal decentralization. Clarifying local governments' financial responsibilities and the distribution of EPT revenues is crucial for motivating authorities to effectively address haze pollution. A larger share of EPT revenue should be allocated to local governments to provide the financial resources necessary for environmental protection and pollution control.

(3) Enhance green performance evaluation. The officials' evaluation system should integrate haze control effectiveness as a key criterion in promotion assessments. This approach will shift the focus from economic growth alone to include environmental achievements, reinforcing officials' environmental responsibilities and promoting sustainable development.

(4) Establish a multi-agent governance mechanism. A collaborative model involving governments, enterprises, and the public is essential for effective haze control. Strengthening public participation and oversight, promoting the benefits of the EPT Law, and improving environmental protection mechanisms will enhance social accountability and contribute to creating a "Beautiful China".

While this study comprehensively evaluates the effectiveness of the EPT Law in mitigating haze pollution, several areas remain for further improvement. First, the analysis relies on regionally aggregated data, which may be influenced by differences in EPT Law enforcement across areas with varying economic conditions, governance capacity, and political priorities. Future research could address this by examining regional enforcement mechanisms and their specific effects on the outcomes of the EPT Law. Second, the study focuses on data from 2011 to 2021, providing insights into short-term impacts. However, a long-term analysis is needed to better understand the evolving effects of the law over time. Finally, future research could explore the EPT Law's impact beyond haze pollution control, examining its broader environmental and economic implications over an extended period. Applying this framework to other countries or regions facing similar environmental challenges could offer a comparative perspective, shedding light on optimizing fiscal decentralization and green tax policies for more effective environmental governance.

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