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Effect of Environmental Courts on Pollution Abatement: A Spatial Difference-in-Differences Analysis

Jingjing Deng ¹, Mingxian Li ¹, Yi Li ² and Jun Lu ^{3,*}

¹ School of Economics, Hunan Agricultural University, Changsha 410128, China; djjheu@163.com (J.D.); limingxian6856@hunau.edu.cn (M.L.)

² College of Tourism, Hunan Normal University, Changsha 410081, China; liyihnu@126.com

³ School of Geography, South China Normal University, Guangzhou 510631, China

* Correspondence: 2019010155@m.scnu.edu.cn; Tel.: +86-18720083011

Abstract: This paper investigates the impact of environmental courts on pollution abatement at the city level, utilizing the establishment of environmental courts in China as a quasi-experiment. A spatial difference-in-differences model is employed to control for the influence of environmental courts on neighbouring non-pilot cities. The results underscore the effectiveness of environmental courts in reducing industrial pollutant emissions, evident in both the pilot areas and adjacent non-pilot areas. The influence of environmental courts on pollution abatement is more pronounced in cities characterized by stronger environmental regulations, higher level of economic agglomeration, and higher level of openness. Mechanism analysis shows that environmental courts promote environmental supervision by governments, public participation in environmental protection, and expenditure on environmental governance by firms. In summary, this paper unveils the tangible effects of environmental courts on pollution abatement and elucidates the mechanisms underpinning this relationship. These findings provide timely implications for regulators concerned with environmental protection.

Keywords: environment courts; pollution abatement; adjacency effect; spatial difference-in-differences



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1. Introduction

Escalating levels of pollution have emerged as a grave issue that constrains China's sustainable development. A report by the Ministry of Ecology and Environment of China indicated that, in 2022, over a third of China's 339 prefecture-level cities breached air quality standards by 37.2 percent [1]. In addition, haze pollution continues to adversely affect the health and well-being of the Chinese population [2]. The Chinese government has implemented various environmental control measures, including an environmental regulation system that employs governmental administrative punishment [3,4] and local administrative intervention, such as the automobile traffic restriction policy [5]. These measures serve as the primary institutional tool for pollution control and play a vital role in preventing the continuous deterioration of the environment. China's market-oriented economic reform has led to the adoption of market-oriented measures, such as emission trading and emission fee collection, which have become essential means for pollution control and have been effective in reducing pollutant emissions [6,7]. However, pollution in China has not been fundamentally reversed, with existing governance efforts only resulting in temporary environmental improvement [8,9]. Environmental protection remains trapped in "campaign-style enforcement", and often results in a rebound, as seen in examples such as "APEC Blue" and "Political Blue" [10,11]. This highlights the persisting lack of pollution control measures in China and emphasizes the need for the establishment of the rule of law to address this issue [12].

The construction of environmental rule of law can be broadly categorized into two aspects: the development of regulations and the strengthening of judicial capacity.

Judicial capacity is a prerequisite to ensuring the correct and effective implementation of laws and regulations [13]. In many cases, numerous legal provisions have been formulated, but due to the lag in building judicial capacity, these laws and regulations have not played their due role. Since the promulgation of the Environmental Protection Law of the People's Republic of China in 1989, hundreds of laws and regulations related to environmental protection have been enacted by both national and provincial legislative bodies [14], providing a legal foundation for pollution control measures. Regrettably, the current state of environmental courts and enforcement in China is inadequate. Since 1998, annual environmental disputes in China have increased by over 20%, and since 2005, by over 30% [15]. In 2016, environmental protection authorities received over 100,000 cases involving pollution and ecological damage, as reported in China's Environment Yearbook 2017. In contrast, during the same period, the people's courts at all levels concluded 13,895 environmental and resource cases, as reported in the Environmental and Resources Adjudication in China (2016–2017). Despite the increasing intensity of pollution infringement disputes, environmental justice in China remains inefficient, with inadequate capacity to handle environmental infringement cases in line with regulations, resulting in poor enforcement outcomes.

An environmental court system was established in the 1950s, which defined and adjudicated environmental violations through a specific environmental and resource-focused adjudication body and provided a judicial approach to resolving environmental disputes [16,17]. In 2007, China initiated an experimental environmental court in Guiyang, followed by several regions that established environmental courts at all levels throughout the country, making this mechanism an essential element in promoting environmental justice to mitigate environmental pollution. However, there is a diversity of opinions regarding these actions, and scholars primarily debate their legality and legitimacy from a judicial standpoint [18,19]. Consequently, rigorous textual analysis of empirical data is urgently necessary. Through empirical evidence, this paper seeks to systematically evaluate the impact of environmental courts on pollution abatement at the city level in China.

China's regional environmental governance exhibits prominent territorialism characteristics. The absence of a formal system in territorialism's administrative environmental governance system often results in fragmentation among local governments, leading to low pollution control efficiency. Moreover, pollution spillover can lead to ambiguity in regional environmental governance responsibilities, causing local governments to become free riders in pollution governance, thereby increasing the difficulty of pollution control [20,21]. Independent environmental governance has proven insufficient in improving overall environmental outcomes. Effective pollution control in China can only be achieved by breaking down administrative barriers and implementing cross-domain collaborative governance. Environmental justice is a critical measure and the final safeguard for protecting the environment. China's environmental courts have been given the right to centralize jurisdiction over cases concerning environmental resources across regions, which mitigates the territorial characteristics of environmental governance. Thus, the implementation of environmental justice in China offers a novel avenue for promoting collaborative pollution control at the regional level. Additionally, the legally binding nature of judicial results obligates the government to enhance environmental law enforcement and disrupt the "collusion between government and business" that hinders pollution control efforts. Central policymakers have included pollution control in the performance assessment system, hence local governments will compete in terms of environmental regulation [22]. Economic activities are often affected by neighbourhood effects [23], in which significant economic and social reforms in one region will inevitably spill over to neighbouring regions. The reform of environmental justice, as a new environmental governance measure, will also have similar spillover effects. Although there is a substantial body of literature on the impact of environmental policies on pollution control, few studies have considered this impact in depth.

This paper seeks to establish a quasi-experiment using the policy experiment initiated by Chinese environmental courts. The primary objective is to employ the difference-in-differences (DID) method, discerning the causal impact of reinforcing environmental justice on pollution control. However, the presence of significant neighbourhood effects from environmental courts may influence both the cities with environmental courts and adjacent cities without environmental courts, violating the DID method's assumption of individual intervention. To address this challenge, we incorporated the neighbourhood effects of a spatial meteorological technology control policy. Subsequently, a spatial difference-in-differences (SDID) model was constructed to accurately identify the effect of environmental courts on pollution abatement. To further enrich our understanding, this paper explores heterogeneity and mechanisms by leveraging multiple channels and original databases, collecting panel data from 285 prefecture-level cities and firms in China, spanning from 2006 to 2022.

This paper contributes on several fronts. First, by utilizing data from prefecture-level cities in China, it establishes a quasi-natural experiment through the implementation of environmental courts. It assesses the impact of environmental courts on pollution abatement in China and employs mathematical models to probe the underlying mechanisms. This empirical analysis offers valuable insights for resolving contentious issues arising from the practical implementation of environmental courts in China. Second, recognizing the proximity effect of policy implementation, this paper employs the SDID model. This model effectively distinguishes the impact of environmental courts on pollution abatement within a region and in neighbouring areas. This enhances the depth of our understanding regarding the operational effects of environmental courts, presenting innovative methodologies and empirical insights for the quantitative analysis of policy effects. Third, we verified the mechanism of environmental courts on promoting regional pollution control from the perspectives of the government, the public, and firms, clarifying the pathways through which environmental judicial enforcement functions and providing valuable supplementary insights into the mechanisms of environmental judicial effectiveness.

The remainder of this paper is constructed as follows. Section 2 provides an overview of the institutional context that led to the establishment of the environmental court. In Section 3, we establish a theoretical model of environmental justice affecting pollution and formulate our research hypotheses. Section 4 explains the methodology, data sources and variables. Section 5 presents the empirical results. The final section concludes with policy implications.

2. Institutional Background

The complex nature of pollution involves numerous stakeholders in the handling process. However, for a prolonged period, China's environmental cases have been managed using a conventional jurisdiction method comprising criminal, civil, and administrative courts, respectively [24]. This simplistic classification approach fails to adequately address the criminal, civil, and administrative aspects of environmental cases, leading to a significant reduction in case efficiency and compromising the integrity of environmental laws and regulations. The absence of specialized environmental justice institutions has hindered the practical effectiveness of existing environmental protection laws and regulations. The inadequacy of the environmental justice system has significantly undermined the role of the rule of law in pollution control.

The establishment of environmental courts marks a pivotal advancement in specialized environmental justice, aligning with the evolving global justice landscape [25]. The world witnessed the inception of the first environmental court, the Land and Environment Court, in New South Wales, Australia, in September 1980 [26]. It was the first court to establish a professional team dedicated to environmental justice, enabling timely and accurate resolution of environmental disputes, improving judicial mediation efficiency, and reducing the costs incurred by litigants seeking environmental justice through judicial means. This model has inspired other regions and countries, such as Vermont, the United States (1990),

and New Zealand (1991), to establish their own environmental courts [27]. Currently, there are more than 40 countries with established environmental courts [28].

Environmental rule of law has become a crucial means for all countries to protect the ecological environment. Compared to other regulatory means, environmental rule of law has more potent binding force and deterrent power. In November 2007, China established its first environmental courts, the Environmental Protection Tribunal of the Intermediate People's Court of Guiyang, and the Environmental Protection Tribunal of the People's Court of Qingzhen City, simultaneously. The Guiyang City Intermediate People's Court subsequently released "designated jurisdiction court cases accepted by the environmental protection scope of the provisions concerning the trial of the destruction of environmental resources" and other guidance documents. These documents specify that the two levels of courts are responsible for the cross-regional trial-related scope of environmental concerns in criminal, civil, and administrative first-instance cases related to environmental issues, as well as relevant enforcement cases. China took the lead in consolidating three categories of environmental cases into one trial and exercising centralized and exclusive jurisdiction over them. Consequently, the proliferation of pilot environmental courts expanded nationwide, significantly contributing to the promotion of the rule of law in China's environmental governance. The formalization of the environmental court system in China took place in July 2014, marked by the announcement from the Supreme People's Court of the People's Republic of China regarding the establishment of the Environmental and Resources Tribunal.

3. Theoretical Model and Hypothesis

Special courts and tribunals have been found to be more efficient in addressing complex social problems, and judicial specialization serves as a theoretical summary of this effective approach [29]. Environmental elements, such as water and atmosphere, are not bound by administrative boundaries and can easily move across regions, resulting in significant spillover effects of pollution [30]. The resolution of environmental problems necessitates collaboration between adjacent administrative regions. China's environmental justice system promotes a centralized jurisdiction mechanism that uses an ecosystem or ecological functional area as a unit to exercise jurisdiction across administrative boundaries. For instance, the superior people's courts in Hubei, Guangdong, Hebei, Qinghai, and Xinjiang have empowered the intermediate people's courts under their jurisdiction to exercise centralized authority over environmental civil public interest litigation cases spanning administrative boundaries. Since 26 October 2017, the No. 4 Intermediate People's Court of Beijing has been handling administrative appeals for environmental protection cases originally heard by the Tianjin Railway Court. The establishment of environmental courts is anticipated to lead to a reduction in pollution levels within the region and an improvement in environmental quality in neighbouring areas. To comprehensively grasp the impact of the establishment of an environmental court on pollution control in neighbouring areas, this paper aims to develop an intergovernmental evolutionary game model and a firm-level decision-making model for a detailed elaboration. To analyse the influence mechanism of local government competition on environmental pollution, this paper refers to Smith's approach [31], which provides an in-depth discussion on the combination of environmental governance strategies that two local governments may adopt. The definitions of symbols involved in the process of model construction are described in Appendix A, Table A1.

Assuming there are two local governments, referred to as a and b , engaging in a repeated random game. After implementing (or not) environmental governance policies, the reduction (or increase) of regional pollutant emission of a and b is presented by R_a (I_a) and R_b (I_b), respectively. Pollution control costs are represented by C_a and C_b , respectively. The probabilities of governments a and b implementing environmental governance policies are n and m , respectively. Assume the externalities from government a to government b and vice versa are represented by α_1 and α_2 , respectively, and a reward M is given for implementing environmental governance policies, while a punishment F is given for

not implementing them, and $F > M$. σ is the weight of environmental performance in performance evaluation ($0 < \sigma < 1$). Based on the above assumptions, the dynamic equation for the environmental governance behaviour of government a and government b is as follows:

The expected revenues (U_1 and U_2) for government a 's implementation of environmental governance policies are:

$$U_1 = m[-C_a + \sigma(R_a + \alpha_2 R_b)] + (1 - m)[-C_a + \sigma(R_a - \alpha_2 I_b) + M] \quad (1)$$

$$U_2 = m[\sigma(-I_a + \alpha_2 R_b) - F] + (1 - m)[\sigma(-I_a - \alpha_2 I_b)] \quad (2)$$

The average return $\bar{U}$ of government a is:

$$\bar{U} = nU_1 + (1 - n)U_2 \quad (3)$$

The expected revenues (V_1 and V_2) of government b 's implementation of environmental governance are:

$$V_1 = n[-C_b + \sigma(R_b + \alpha_1 R_a)] + (1 - n)[-C_b + \sigma(R_b - \alpha_1 I_a) + M] \quad (4)$$

$$V_2 = n[\sigma(-I_b + \alpha_1 R_a) - F] + (1 - n)[\sigma(-I_b - \alpha_1 I_a)] \quad (5)$$

The average return $\bar{V}$ government b is:

$$\bar{V} = mV_1 + (1 - m)V_2 \quad (6)$$

The framework of evolutionary game theory requires that the dynamic equations for the implementation of governance policies by governments a and b to choose to implement environmental governance are as follows:

$$Q(n, m) = \frac{dn}{dt} = n(1 - n)(U_1 - U_2) = n(1 - n)[\sigma(R_a + I_a) + (1 - m)M + mF - C_a] \quad (7)$$

$$H(n, m) = \frac{dm}{dt} = m(1 - m)(V_1 - V_2) = m(1 - m)[\sigma(R_b + I_b) + (1 - n)M + nF - C_b] \quad (8)$$

Let $\frac{dn}{dt}$, $\frac{dm}{dt}$ equal 0, then the local equilibrium point of the replicator dynamic equation is $(0, 0)$, $(1, 1)$, $(0, 1)$, $(1, 0)$, and $(\frac{C_b - M - \sigma(R_b + I_b)}{F - M}, \frac{C_a - M - \sigma(R_a + I_a)}{F - M})$. The five local equilibrium points derived from the dynamic equation do not necessarily represent evolutionarily stable strategies of the system. To examine the local stability of the Jacobian matrix (J) based on Friedman's theory [32], two conditions must be simultaneously satisfied: $tr(J) < 0$ and $det(J) > 0$, so the evolutionarily stable strategy of the system can be determined. At the point $(\frac{C_b - M - \sigma(R_b + I_b)}{F - M}, \frac{C_a - M - \sigma(R_a + I_a)}{F - M})$ is not satisfied $tr(J) < 0$. Therefore, this equilibrium point is not an evolutionarily stable strategy for the system.

According to the replicator dynamic equation, when $n > \frac{C_b - M - \sigma(R_b + I_b)}{F - M}$, $m = 1$ is stable; when $m > \frac{C_a - M - \sigma(R_a + I_a)}{F - M}$, $n = 1$ is stable. This implies that when the local government is inclined to implement environmental governance policies, neighbouring local governments will gradually adopt the same strategy. Establishing environmental courts will allow for a stricter enforcement of environmental governance policies, ultimately promoting environmental policy compliance. As the weight of environmental governance increases in government performance assessment, local governments will prioritize the environment, leading to a "race to the top" in competitive strategies, resulting in an outcome of $(1, 1)$. Therefore, we propose the following hypothesis:

Hypothesis 1. *Establishing an environmental court will improve the government's environmental control and encourage a "race to the top" among governments to achieve better environmental control, ultimately promoting pollution control in both the local and nearby areas.*

The establishment of environmental courts provides an efficient judicial mechanism for the public to protect their rights and participate in environmental conservation. This encourages public participation in environmental protection and reveals firms' pollution behaviour. When an environmental court identifies an environmental violation by a firm, it will penalize the illegal behaviour. In today's fast-paced information environment, punitive judgements produce an announcement effect, leading residents to reduce their consumption of the firm's products [33]. This paper tests the influence of environmental courts on the pollution control behaviour of firms by improving public participation in environmental protection and clarifies the mechanism of the establishment of environmental courts for pollution control in a region and neighbouring areas, based on the theoretical framework of Campa [34].

Assume that firms can produce either a cleaner version (e_c) or a less clean version (e_d), and corresponding production costs are c_c and c_d , respectively, where $c_c > c_d$. The demand from residents for the product is y , derived from both the local market (y_l) and other markets (y_n). Residents derive utility $\phi(y_l)$ from the job opportunities provided by firms, subject to the following properties: $\phi'(y_l)$, $\phi''(y_l)$. Simultaneously, residents are subject to health damage and environmental loss caused by the pollution discharge from firms (h), which depends on production technology and yield and satisfies: $h(y_l, e_c)$, $h(y_l, e_d) = \bar{h}(y_l) > 0$, $\bar{h}'(y_l) > 0$, $\bar{h}''(y_l) > 0$. Let the initial endowment of residents be S . If the firms' output is 0, their marginal revenue exceeds the marginal loss, that is $\phi'(0) > h'(0)$. According to the cost-benefit principle, firms choose between using a cleaner or less clean production technology, which corresponds to different levels of pollution emissions. The consumption preferences of residents are influenced by the production technology used by firms [35]. If residents are aware that a firm produces using less clean technology, they will reduce their consumption of the firm's goods [36]. However, in general, only a few residents in the vicinity of the firm are aware of its production technology, and the impact of this on the overall market is negligible. The establishment of an environmental court provides a new avenue for local residents to protect their environment. The court's verdict can attract more attention and affect a firm's market share. π denotes the probability of a firm being sued by the public for environmental infringement. The further a firm is from the environmental court, the lower π will be. This is because the costs of litigation are higher for firms located further away from the court. Despite this, the Supreme Court of the People's Republic of China has promoted the establishment of a centralized jurisdiction system to address environmental legal cases across administrative regions. The conditions for maximizing resident utility are as follows:

$$\begin{aligned} \max_{y_l, y_n} R &= E[y_l + y_n + \phi(y_l) - h(y_l, e_j)] \\ \text{s.t. } y_l + y_n &\leq S \end{aligned} \quad (9)$$

Residents allocate their initial wealth S to purchase commodities from both local and other domestic markets to maximize their utility. Since the initial wealth S is given, we can determine y_l once we have determined y_n . For y_l , we arrive at the maximum value of $[\phi(y_l) - h(y_l, e_j)]$, where $p_r = 1$ indicates that the firm is being sued by the environmental court, while $p_r = 0$ means otherwise. Residents can determine the production technology adopted by firms through the environmental court trial results, and subsequently make informed consumption choices.

$$y_l^* = \argmax [\phi(y_l) - (1 - \psi(e_c|p_r))\bar{h}(y_l)] \quad (10)$$

where $\psi(e_c|p_r)$ represents the probability that a firm chooses cleaner production technology and meets the following conditions:

$$\psi(e_c|p_r) = \begin{cases} \psi\left[\left(\bar{y}_l - \underline{y}_l\right)\pi \geq c_c - c_d\right] = \gamma & \text{if } p_r = 0 \\ 0 & \text{if } p_r = 1 \end{cases} \quad (11)$$

where $\bar{y}_l = \operatorname{argmax} [\phi(y_l) - (1 - \gamma)\bar{h}(y_l)]$ and $\underline{y}_l = \operatorname{argmax} [\phi(y_l) - \bar{h}(y_l)]$. Firms face a cost–benefit analysis when deciding whether to adopt cleaner production technology. If the cost of a potential lawsuit resulting from less clean production technology exceeds the cost of transitioning to cleaner production technology, the firm will choose the latter; otherwise, it will continue polluting. Therefore, the consumers' optimal choice is:

$$y_l^* = \begin{cases} \bar{y}_l & \text{if } p_r = 0 \\ \underline{y}_l & \text{if } p_r = 1 \end{cases} \quad (12)$$

The expected earnings of firms that adopt cleaner technology and less clean technology are, respectively: $R(e_c) = R_c = \bar{y}_l - c_c$ and $R(e_d) = R_d = (1 - \pi)(\bar{y}_l - c_d) + \pi(\underline{y}_l - c_d)$.

According to the cost–benefit principle, the conditions for firms to choose cleaner technology production are as follows: $R_c > R_d$, which is $(\bar{y}_l - \underline{y}_l)\pi > c_c - c_d$. Thus, the production technology selection strategy of a firm can be expressed as:

$$e_j = \begin{cases} e_c & \text{if } (\bar{y}_l - \underline{y}_l)\pi > c_c - c_d \\ e_d & \text{otherwise} \end{cases} \quad (13)$$

As is evident from Equation (13), as the value of π increases, firms are more inclined towards utilizing cleaner technology to lower their industrial pollution emissions. Environmental courts can handle environmental cases across administrative regions; consequently, firms situated in other regions may also face the impacts of the court's establishment. However, the probability of being sued decreases with the increasing distance from the court, mainly due to the associated litigation costs. Therefore, the pollution control effect of an environmental court is more significant in the local region compared to its neighbouring regions, and the effectiveness decreases as the distance increases. Thus, we propose the following hypotheses:

Hypothesis 2. *Establishing environmental courts can enhance public participation in environmental protection, increase enterprise expenditure on pollution control and promote pollution control not only in the local area but also in neighbouring regions.*

Hypothesis 3. *The effect of the environmental court's pollution control is more pronounced in the local area than in neighbouring regions, and it gradually decreases as the distance from the court increases.*

4. Methodology and Data

4.1. Methodology

The main objective of this empirical study is to accurately establish the causal relationship between the strengthening of environmental justice and pollution control and distinguish the local and neighbouring effects of pollution control. Since the establishment of the environmental court in Guiyang City in 2007, several regions in China have also implemented similar courts. This quasi-experiment offers a valuable opportunity for this paper to analyse empirically the impact of the strengthened environmental justice on China's pollution control. This paper uses the DID method, which is commonly used in policy impact assessment, to quantitatively analyse the changes in industrial pollutant emissions before and after the establishment of environmental courts and to assess the impact on pollution controls exerted by an enhancement in environmental justice. The basic regression model is presented as follows:

$$E_{it} = \beta_0 + \beta_1 \text{legal}_{it} + X_{it}\delta + \mu_i + \lambda_t + \varepsilon_{it} \quad (14)$$

where i represents the city, t represents the year, E_{it} represents the emission index of industrial pollutants, legal_{it} is a dummy variable, represents whether an environmental

court is set up in the year t of city i , μ_i represents the fixed effect of region, λ_t represents the fixed effect of time, and X represents other control variables; ε_{it} is an error term.

According to the principles of the DID model, the coefficient β_1 represents the net impact of the environmental court on pollution abatement. The identification of the DID model's parameters requires meeting certain prerequisites, including the stable unit treatment value assumption (SUTVA). The SUTVA requires that there be no interaction between potential outcomes of different individuals, meaning the potential outcome of each individual is independent of the intervention status of other individuals [37]. However, in social sciences, especially economics, the assumption that there is no interactive influence may not be valid since the research object is often human behaviour, and there is often interactive influence between individual behaviours [38]. According to the theoretical analysis above, the establishment of the environmental court will affect the pollution emissions in the region and interfere with those in neighbouring areas. As a result, the establishment of this quasi-experiment by the environmental court violates the SUTVA, and using Equation (14) to evaluate the impact of the strengthening of environmental justice on pollution control is biased. To address the neighbourhood effects of policy implementation, this paper employs the SDID method proposed by Heckert and Mennis [39]. The SDID model combines the spatial Durbin model (SDM) with the DID model to clarify the influence of policy implementation in different regions by decomposing the spatial weight matrix. The SDM can consider the spatial correlation of independent variables and dependent variables simultaneously, which helps prevent the error of missing variables. In selecting spatial econometric models, the SDID model should be given priority [40]. Therefore, in this paper, we adopt the SDM as the basic model and combine it with the DID model to construct the SDID model. The specific form is as follows:

$$E_{it} = \beta_0 + \rho \sum_j w_{ij} E_{jt} + \beta_1 legal_{it} + \theta \sum_j w_{ij} legal_{jt} + X_{it} \delta + \kappa \sum_j w_{ij} X_{jt} + \mu_i + \lambda_t + \varepsilon_{it} \quad (15)$$

where w_{ij} is the element in row i and column j of the spatial weight matrix W . To discuss the specific path of pollution emission reduction caused by the neighbourhood effects of environmental courts, the following three spatial weight matrices are constructed in this paper. The first is the standard spatial adjacency matrix (W_1); if region i is geographically adjacent to region j , then $w_{ij} = 1$; otherwise, it is 0. The second is the geographical distance weight matrix (W_2), where the element w_{ij} represents the reciprocal of the nearest highway mileage in region i and region j . Regional economic development levels are spatially correlated and, to bolster the robustness of the analysis results, this paper constructed a spatial weight matrix (W_3) that incorporates both geographical and economic distances. The elements w_{ij} are determined as the reciprocal of the nearest highway mileage between region i and region j , multiplied by the proportion of the average per capita GDP in the respective regions. Theoretically, the matrix W_3 considers both geographical distance and the regional spillover and radiation effect of economic factors, providing a more comprehensive and objective measure of the degree of spatial correlation among cross-section units. Coefficient θ reflects the average effect of the establishment of environmental courts on pollution control in neighbouring areas, but it does not strictly differentiate between cross-influence among the experimental group cities and the spillover influence of these cities on the control group cities. To address this issue, this paper adopts the approach of Chagas, Azzoni, and Almeida [41] and decomposes the matrix W into the variable W_{legal} in the following forms:

$$W = W_{T,T} + W_{T,NT} + W_{NT,T} + W_{NT,NT} \quad (16)$$

where $W_{T,T} = \Omega_t \times W \times \Omega_t$, $W_{T,NT} = \Omega_t \times W \times \Omega_t^c$, $W_{NT,T} = \Omega_t^c \times W \times \Omega_t$, and $W_{NT,NT} = \Omega_t^c \times W \times \Omega_t^c$; $\Omega_t = \text{diag}(legal_t)$ is a matrix whose main diagonal element is $legal_{it}$; $n \times n$ is a matrix where the rest of the entries are 0; $\Omega_t^c = \text{diag}(1_n - legal_t)$; 1_n

is a $n \times 1$ column vector whose entries are all 1. Substitute (16) into (15) to obtain the following model:

$$E_{it} = \beta_0 + \rho \sum_j w_{ij} E_{jt} + (\theta_1 \sum_j w_{(T,T)ij} + \theta_2 \sum_j w_{(NT,T)ij} + \theta_3 \sum_j w_{(T,NT)ij} + \theta_4 \sum_j w_{(NT,NT)ij}) legal_{jt} + \beta_1 legal_{it} + X_{it} \delta + \kappa \sum_j w_{ij} X_{jt} + \mu_i + \lambda_t + \varepsilon_{it} \quad (17)$$

where $W_{(T,NT)ij} = \begin{cases} w_{ij} & \text{if } \Omega_{it} = \Omega_{jt}^c = 1 \\ 0 & \text{otherwise} \end{cases}$, $W_{(NT,NT)ij} = \begin{cases} w_{ij} & \text{if } \Omega_{it} = \Omega_{jt}^c = 1 \\ 0 & \text{otherwise} \end{cases}$. From that, when and only when $legal_{it} = 0$, $W_{(T,NT)ij}$, and $W_{(NT,NT)ij}$ is not 0. Hence, $w_{(T,NT)ij} \times legal_{it} = 0$ and $w_{(NT,NT)ij} \times legal_{it} = 0$.

Then (17) could be simplified as:

$$E_{it} = \beta_0 + \rho \sum_j w_{ij} E_{jt} + (\theta_1 \sum_j w_{(T,T)ij} + \theta_2 \sum_j w_{(NT,T)ij}) legal_{jt} + \beta_1 legal_{it} + X_{it} \delta + \kappa \sum_j w_{ij} X_{jt} + \mu_i + \lambda_t + \varepsilon_{it} \quad (18)$$

where θ_1 and θ_2 , respectively, represent cross effects between the areas where the environmental court is established and the spillover effect of the areas where the environmental court is established on the areas where it is not established.

4.2. Data

This paper constructs a data panel of 285 cities in China from the year 2006 to 2022. The dependent variable is pollution emissions. We use wastewater emissions (Water), sulphur dioxide emissions (SO_2), and nitrogen oxide (NO_X) to represent pollution emissions. We take the natural logarithm of these variables to address excessive skew. The key independent variable is environmental courts, measured by a dummy variable *legal*, which equals 1 if environmental courts have been established.

To mitigate the impact of city-level heterogeneity on the results, we introduce the following control variables to account for city characteristics: GDP per capita (*pgdp*); foreign direct investment (*fdi*), measured by the ratio of foreign direct investment to GDP; industrial structure (*sec*), measured by the output share of the second industry; total population (*pop*), defined as the natural logarithm of the total population in the city; technology level (*rd*), measured by the proportion of R&D employees to total employees; and resource abundance (*re*), measured by the number of workers in extractive industries.

The data for the environmental courts are manually compiled from legal websites and the websites of the intermediate people's courts of prefecture-level cities. Data for other variables primarily originate from reputable sources such as the China City Statistical Yearbook, the China Statistical Yearbook for Regional Economy, and the CEIC database.

5. Empirical Results and Analysis

5.1. Baseline Results

The results in Table 1 demonstrate that the establishment of environmental courts in each region significantly reduces the total amount of wastewater emissions, sulphur dioxide emissions, and nitrogen oxide emissions. The strengthening of environmental justice, marked by the establishment of environmental courts, significantly affects pollution control.

In the prefecture-level cities of China, an inverted U-shaped relationship between economic development and pollution is evident. The environmental Kuznets curve is essentially validated, accounting for control variables. Foreign direct investment (*fdi*) emerges as a mitigating factor in environmental pollution. It achieves this by fostering pollution halo and technology spillover effects, enhancing the host country's environmental protection technologies, and consequently reducing the emission of industrial pollutants. Conversely, the development of secondary industry is notably associated with a significant increase in the emission of industrial pollutants. This is likely due to China's long history of producing high levels of consumption, emissions, and pollution. Although this production mode has been tentatively contained, its transformation remains challenging. Higher R&D

intensity is positively associated with total industrial pollution emissions, suggesting that R&D investment in China may be skewed towards production technology rather than green technology. This investment bias may contribute to large-scale expansion of production and synergistically exacerbate industrial pollution. Population density is positively correlated with industrial sulphur dioxide emissions and haze pollution. Higher population densities drive greater material demand, which promotes the growth of industrial production and elevates industrial pollutant emissions. Resource abundance exacerbates regional pollution, and abundant natural resources may crowd out investment in scientific and technological research, thereby hampering a region's ability to innovate in energy conservation and emission reduction.

Table 1. Effect of environmental courts on pollution abatement.

Variables	(1)	(2)	(3)
	lnWater	lnSO ₂	lnNO _x
Legal	−0.0618 *	−0.0531 **	−0.0471 ***
	(0.0351)	(0.0226)	(0.0120)
lnpgdp	0.8321 *	2.4312 ***	1.1141 **
	(0.4799)	(0.6954)	(0.5526)
(lnpgdp) ²	0.0365	−0.0992 ***	−0.1122 ***
	(0.0256)	(0.0314)	(0.0333)
Fdi	−1.4875 **	−1.1095 **	−1.1397 ***
	(0.6988)	(0.4834)	(0.3066)
Sec	0.1315 **	0.3709 ***	0.2413 *
	(0.0651)	(0.1109)	(0.1256)
Rd	0.1140 **	0.1113 **	0.0714 **
	(0.0571)	(0.0554)	(0.0336)
Pop	0.2824	0.2185 **	0.1194 ***
	(0.2409)	(0.1069)	(0.0447)
Re	0.0440 *	0.0448 **	0.0189 ***
	(0.0252)	(0.0220)	(0.0056)
Year-fixed effect	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes
Province × year-fixed effect	Yes	Yes	Yes
Observations	4845	4845	4845
Adjusted R ²	0.8952	0.8781	0.8841

Notes: standard errors in parentheses. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Environmental courts, on average, can reduce industrial wastewater emissions by 6.18%, industrial sulphur dioxide emissions by 5.31%, and industrial nitrogen oxide by 4.71%. Judicial means have a broader scope of influence and a more substantial mandatory effect than other emission reduction measures and can regulate the environmental behaviours of multiple subjects simultaneously, including the government, enterprises, and the public [26]. In theory, the reinforcement of environmental justice is expected to exert a substantial and negative influence on environmental pollution. However, the estimated results reveal a comparatively modest impact of environmental justice on pollution abatement. This could be attributed to two factors: (1) a violation of the parallel trend hypothesis, indicating a tendency for pollution levels between the experimental and control groups to diverge before policy implementation; and (2) a breach of the hypothesis of stable individual intervention, wherein policy implementation in the treatment group positively spills over to the control group. To delve into the underlying causes, this paper initiates a parallel trend test and subsequently employs the event study method proposed by Beck, Levine, and Levkov [42]. The results, as presented in Table 2, demonstrate that prior to the establishment of the environmental court there were no significant differences in total industrial pollution emissions between the treatment and control groups. This finding supports the parallel trend hypothesis. In addition, the implementation of the environmental court's policies gradually emerged two years after its establishment, which helped to

improve the pollution situation in the region over time. Therefore, it is necessary to test the hypothesis of stable individual intervention and use spatial measurement technology to identify the effect of environmental justice's pollution control to obtain its net effect.

Table 2. Parallel trend test.

Variables	(1)	(2)	(3)
	lnWater	lnSO ₂	lnNO _x
<i>treated</i> × <i>legal</i> ^{−1}	−0.0155 (0.0417)	0.0280 (0.0438)	0.0167 (0.0160)
<i>treated</i> × <i>legal</i> ⁰	−0.0205 (0.0493)	0.0398 (0.0543)	0.0117 (0.0008)
<i>treated</i> × <i>legal</i> ¹	−0.0404 (0.0596)	0.0420 (0.0689)	−0.0231 * (0.0125)
<i>treated</i> × <i>legal</i> ²	−0.0534 (0.0634)	−0.0276 (0.0384)	−0.0276 * (0.0157)
<i>treated</i> × <i>legal</i> ³	−0.0418 ** (0.0166)	−0.0437 ** (0.0191)	−0.0766 *** (0.0211)
<i>treated</i> × <i>legal</i> ⁴	−0.1002 ** (0.0468)	−0.0797 ** (0.0331)	−0.0927 *** (0.0328)
<i>treated</i> × <i>legal</i> ⁵	−0.2620 ** (0.1283)	−0.0857 ** (0.0340)	−0.0954 *** (0.0330)
<i>treated</i> × <i>legal</i> ⁶	−0.3049 * (0.1618)	−0.2190 ** (0.0896)	−0.0971 *** (0.0374)
<i>treated</i> × <i>legal</i> ⁷	−0.2744 ** (0.1335)	−0.2953 ** (0.1264)	−0.1419 *** (0.0406)
<i>treated</i> × <i>legal</i> ⁸	−0.2645 ** (0.1048)	−0.2853 ** (0.1374)	−0.1379 *** (0.0467)
Controls	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes
Province × year-fixed effect	Yes	Yes	Yes
Observations	4845	4845	4845
Adjusted R ²	0.8729	0.8868	0.8925

Notes: standard errors in parentheses. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

5.2. Effect of Environmental Courts on Neighbourhood Areas

Table 3 presents the results considering the spatial proximity effect of environmental justice on strengthening pollution control. From the perspective of environmental pollution alone, the spatial lag coefficient is positive, with a significance level of 1% in all weight matrixes, which strongly indicates that China's city-level environmental pollution exhibits noticeable spatial clustering features. These patterns are propelled by natural factors, such as the transregional flow of air and water, as well as by social and economic activities. Moreover, the environmental pollution level in this region exhibits a close relationship with that of its neighbouring regions. This indicates that strengthening regional cooperation in environmental pollution treatment is essential, as unilateral environmental treatment may result in inter-regional pollution leakage and render pollution control efforts futile. The effectiveness of environmental courts in controlling pollution is evident, as they not only reduce pollution in the region but also improve the environmental situation in neighbouring areas. For instance, using the W_3 spatial matrix, strengthening environmental justice can decrease the total emission of industrial waste by 8.46% and industrial sulphur dioxide by 4.94% in the neighbouring control group cities, demonstrating the substantial positive spillover effect of establishing the environmental court on pollution control in adjacent areas, both economically and geographically. Furthermore, the establishment of environmental courts can induce a certain cross-effect among cities in adjacent economic and geographical groups, fortifying the effectiveness of pollution control measures. However, constructing a quasi-experiment based on the establishment of environmental courts

poses challenges to the SUTVA. The utilization of traditional linear panel data models to assess the impact of environmental court establishment on environmental pollution may introduce a downward bias to the estimation coefficient. Therefore, the SDID model employed in this paper is deemed more appropriate for isolating the causal effect of environmental court establishment. Compared to the results presented in Table 1, accounting for the cross-effects and spillover effects of environmental court establishment, the absolute value of the estimated coefficient of legal increased significantly. This further underscores the rationale behind adopting the SDID model in this paper.

Table 3. Effect of environmental courts on pollution abatement considering spatial effects.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	W_1			W_2			W_3		
	lnWater	lnSO ₂	lnNO _x	lnWater	lnSO ₂	lnNO _x	lnWater	lnSO ₂	lnNO _x
WE	0.2597 *** (0.0264)	0.3117 *** (0.0255)	0.1786 *** (0.0232)	0.6443 *** (0.0571)	0.8581 *** (0.0250)	0.7843 *** (0.0645)	0.3654 *** (0.0732)	0.7582 *** (0.0353)	0.6043 *** (0.0420)
legal	−0.1413 *** (0.0474)	−0.1834 *** (0.0547)	−0.1031 ** (0.0492)	−0.1772 *** (0.0531)	−0.0698 ** (0.0326)	−0.0536 ** (0.0254)	−0.1548 *** (0.0474)	−0.0683 ** (0.0334)	−0.1617 *** (0.0561)
$W_{T,T}legal$	−0.0478 *** (0.0163)	−0.0915 (0.0581)	−0.0801 (0.0522)	−0.7488 *** (0.2565)	−0.7012 ** (0.2968)	−0.6947 ** (0.3025)	−0.0689 *** (0.0178)	−0.0578 (0.0444)	−0.0899 (0.0595)
$W_{NT,T}legal$	−0.0220 (0.0251)	−0.1038 *** (0.0289)	−0.0236 (0.0243)	−0.3021 (0.2604)	−0.8141 *** (0.3123)	0.7638 ** (0.3245)	−0.0846 ** (0.0407)	−0.0494 * (0.0297)	−0.0602 ** (0.0277)
X	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WX	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4845	4845	4845	4845	4845	4845	4845	4845	4845

Notes: standard errors in parentheses. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

5.3. Heterogeneity

The effectiveness of the environmental court in terms of pollution control is also influenced by regional environmental regulations. Regions with high levels of environmental regulation are often associated with the strong administrative capabilities of the government, resulting in effective execution of environmental justice and improved pollution control outcomes. In addition, in recent years, the central government has placed increased emphasis on environmental performance evaluation, leading to the phenomenon of “race to the top” in regional environmental regulation as a means of political evaluation. Consequently, rigorous local environmental regulation indirectly promotes environmental regulation in neighbouring areas, resulting in a stronger effect of environmental justice on pollution reduction. To verify this heterogeneity, we adopted the methodology of Hao et al. [43] and calculated the comprehensive indices of sulphur dioxide and wastewater emissions in each region to measure the intensity of regional environmental regulation (ER). We then constructed interaction terms to conduct empirical tests, and the results presented in Table 4 indicate that the pollution control effect of environmental courts is further strengthened with the improvement of environmental regulation. From the perspective of neighbouring areas, a higher level of environmental regulation amplifies the positive spillover effect of environmental courts on pollution control. The inception of the environmental court signals the reinforcement of environmental justice, and rigorous enforcement of environmental laws acts as a foundational element for bolstering pollution control through environmental justice. Effective environmental pollution control can only be achieved through a beneficial interaction between administration and justice.

Secondly, the degree of regional economic agglomeration also affects the enhancement of environmental justice and the pollution reduction effect in this region and its neighbouring regions. According to the theory of agglomeration economics, the agglomeration has spillover effects and scale effects. The spatial concentration of elements in a region reduces costs and improves efficiency, attracting capital investment, human resources, education, technology, medical care, and other resources that improve the overall economy, social efficiency, and law enforcement ability. Therefore, greater environmental justice

strengthens pollution reduction in this region. Its positive spillover effects are stronger in the regions with high economic agglomeration. Moreover, regional economic development often exhibits an agglomeration trend, where an economic region tends to follow the high agglomeration of neighbours and vice versa [44]. As such, the enhancement of environmental justice in regions with a high degree of economic agglomeration will likely have a greater impact on pollution reduction in neighbouring regions, influenced by both endogenous and exogenous factors. Economic agglomeration refers to the density of economic activities per unit area, while output density, which measures the number of economic activities per unit area, is an excellent indicator of a region's economic agglomeration [45]. We measure the degree of economic agglomeration (ag) by computing the ratio of each city's non-agricultural output to the sum of its administrative area, allowing us to explore the relationship between economic agglomeration and environmental justice. The results in Table 5 show that in regions with high economic agglomeration, the pollution control effect of environmental court establishment is more pronounced. Meanwhile, the positive spillover effect of environmental court establishment on pollution control in neighbouring regions is also enhanced with the growth of economic agglomeration. At a certain level of economic agglomeration, the spatial concentration of economic activities has a significant energy-saving and emission reduction effect compared to the decentralized production mode. A higher level of economic agglomeration can synergize with environmental judicial reforms, symbolized by the establishment of environmental courts, to jointly promote environmental pollution governance.

Table 4. Heterogeneity analysis based on environmental regulation.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	W ₁			W ₂			W ₃		
	lnWater	lnSO ₂	lnNO _x	lnWater	lnSO ₂	lnNO _x	lnWater	lnSO ₂	lnNO _x
WE	0.2486 *** (0.0265)	0.3097 *** (0.0256)	0.1806 *** (0.0232)	0.6630 *** (0.0547)	0.8709 *** (0.0481)	0.3072 *** (0.0211)	0.4055 *** (0.0703)	0.7724 *** (0.0586)	0.7132 (0.0632)
legal × er	−0.8207 *** (0.1308)	−0.5868 *** (0.1510)	−0.5501 ** (0.2610)	−0.0058 ** (0.0023)	−0.0199 ** (0.0083)	−0.6707 *** (0.2399)	−0.0168 ** (0.0067)	−0.0217 ** (0.0088)	−0.0313 (0.0089)
W _{T,T} legal × er	−0.0803 *** (0.0131)	−0.0560 *** (0.0149)	−0.5374 ** (0.2109)	−0.1009 ** (0.0486)	−0.0421 (0.0559)	−0.0659 *** (0.0240)	−0.0922 ** (0.0429)	−0.0375 (0.0495)	−0.0524 (0.0623)
W _{NT,T} legal × er	−0.0024 *** (0.0007)	−0.0474 *** (0.0172)	−0.0117 ** (0.0005)	−0.0198 *** (0.0007)	−0.2643 *** (0.0382)	−0.0512 *** (0.0103)	−0.0106 ** (0.0044)	−0.2372 *** (0.0331)	−0.2452 (0.0422)
X	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WX	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4845	4845	4845	4845	4845	4845	4845	4845	4845

Notes: standard errors in parentheses. ** $p < 0.05$; *** $p < 0.01$.

Table 5. Heterogeneity analysis based on economic agglomeration.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	W ₁			W ₂			W ₃		
	lnWater	lnSO ₂	lnNO _x	lnWater	lnSO ₂	lnNO _x	lnWater	lnSO ₂	lnNO _x
WE	0.2436 *** (0.0266)	0.3055 *** (0.0254)	0.1796 *** (0.0231)	0.6363 *** (0.0581)	0.8616 *** (0.0558)	0.7843 (0.0642)	0.3684 *** (0.0702)	0.7316 *** (0.0579)	0.2961 *** (0.0211)
legal × ag	−0.0211 (0.0794)	−0.5196 *** (0.0902)	−0.0732 (0.0837)	−0.1647 * (0.0841)	−0.2881 *** (0.0958)	−0.2524 *** (0.0842)	−0.1546 * (0.0877)	−0.3598 *** (0.1003)	−0.4448 *** (0.0945)
W _{T,T} legal × ag	−0.1202 (0.0811)	−0.1859 ** (0.0923)	−0.1532 * (0.0846)	−0.5542 *** (0.1866)	−0.1265 (0.2129)	−0.1853 (0.2325)	−0.4838 *** (0.1745)	−0.0115 (0.1993)	0.1451 (0.0954)
W _{NT,T} legal × ag	−0.1971 *** (0.0365)	−0.3389 *** (0.0416)	−0.0788 *** (0.0194)	−0.3058 *** (0.0586)	−0.5844 *** (0.0671)	−0.4373 *** (0.0538)	−0.2544 *** (−4.9312)	−0.5326 *** (−9.0254)	−0.1613 *** (−7.3568)
X	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WX	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4845	4845	4845	4845	4845	4845	4845	4845	4845

Notes: standard errors in parentheses. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

In addition, the level of regional openness can impact the effect of environmental justice on pollution control. Greater levels of openness correspond to more competitive markets. Law enforcement is a crucial mechanism for environmental protection and maximizing the effect of environmental justice on pollution control. Meanwhile, regions with high levels of openness tend to be the economic hubs of the region and are more connected with neighbouring areas. Consequently, enhancing environmental justice in highly open regions can lead to more significant pollution control in neighbouring areas. To test this heterogeneity, the ratio of the total import and export value to the gross domestic product is used to measure the level of openness (open). The results in Table 6 show that improving openness is conducive to promoting environmental pollution control. With increased openness, the pollution control effect of environmental courts will be strengthened.

Table 6. Heterogeneity analysis based on level of openness.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	W ₁			W ₂			W ₃		
	lnWater	lnSO ₂	lnNO _x	lnWater	lnSO ₂	lnNO _x	lnWater	lnSO ₂	lnNO _x
WE	0.2606 *** (0.0263)	0.3116 *** (0.0255)	0.1795 *** (0.0232)	0.6139 *** (0.0610)	0.8731 *** (0.0463)	0.7032 *** (0.0489)	0.3524 *** (0.0706)	0.7526 *** (0.0593)	0.7122 *** (0.0642)
<i>legal</i> × <i>open</i>	−0.0118 (0.0855)	−0.6352 *** (0.1467)	−0.0724 (0.1211)	−0.2883 ** (0.1457)	−0.2816 * (0.1679)	−0.4144 *** (0.1380)	−0.2931 * (0.1506)	−0.3601 ** (0.1738)	−0.2834 ** (0.1432)
<i>W_{T,T}legal</i> × <i>open</i>	−0.3404 ** (0.1524)	−0.0921 (0.1749)	−0.3967 *** (0.1283)	−1.8163 *** (0.3961)	−1.1395 ** (0.4569)	−0.1596 (0.1461)	−1.6092 *** (0.3670)	−0.9989 ** (0.4234)	0.8424 ** (0.3552)
<i>W_{NT,T}legal</i> × <i>open</i>	−0.2213 *** (0.0556)	−0.3076 *** (0.0639)	−0.2083 *** (0.0512)	−1.1889 *** (0.1887)	−1.3796 *** (0.2178)	−0.2498 *** (0.0584)	−0.9366 *** (0.1676)	−1.4008 *** (0.2671)	−1.1447 *** (0.2164)
X	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WX	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4845	4845	4845	4845	4845	4845	4845	4845	4845

Notes: standard errors in parentheses. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

5.4. Mechanism Analysis

The analysis above confirms that strengthening environmental justice helps control pollution in both the region and neighbouring areas, promoting regional coordination for pollution treatment. Based on the theoretical analysis, the establishment of environmental courts will strengthen environmental regulations in the region by creating a promotion incentive effect that fosters a “race to the top” among neighbouring regions. In addition, the establishment of environmental courts has broadened channels for individuals to protect their environmental rights, helped to improve the level of people’s participation in environmental protection, effectively monitored the pollution by firms, and encouraged firms to carry out cleaner production technology. Next, this paper will test the two influencing mechanisms, respectively.

First, we examine the impact of environmental courts on environmental regulation in the region and its surrounding areas. To gauge the magnitude of regional environmental regulation, this paper employs a comprehensive index of pollution emissions specific to each region. Emphasizing the pivotal role of government in fostering environmental regulation, the intensity of environmental regulation is delineated from the standpoint of environmental law enforcement. This is achieved by substituting the dependent variable with the count of administrative penalties imposed for environmental violations by firms (punish). The data for this aspect is sourced from the national environmental monitoring information database of the Institute of Public and Environmental Affairs (available online: <https://www.ipe.org.cn/IndustryRecord/Regulatory.html>, accessed on 20 December 2023), which contains records of most firms in the 338 prefecture-level and other cities that have received administrative penalties for environmental violations since 2009. The DID method is used to identify the impact of the environmental court on environmental regulation. The control variables include the actual GDP per capita, the proportion of the secondary industry’s added value in GDP, and the proportion of foreign direct investment in GDP.

Additionally, the analysis controls for time effects, individual effects, and the trend-fixed effects of the province.

The results presented in Table 7 highlight a significant enhancement of environmental regulation in both the region and neighbouring areas following the establishment of environmental courts. This effect holds true across various indicators of environmental regulation, emphasizing the pivotal role of environmental courts in advancing regulatory measures. These findings align with observable instances from publicly available information. For example, since the inception of the environmental court in Guiyang from 2008 to 2022, it has adjudicated 2942 cases related to water, air, and land pollution. Additionally, from 2009 to 2022, the government increased its investigation and punishment of firms violating environmental laws, leading to 816 cases of administrative punishment, averaging 58 cases per year. Similarly, in its neighbouring cities, Liupanshui, Anshun, and Shaotong, there was a significant increase in the number of administrative penalties for environmental violations during this period, with 512, 598, and 568, respectively, indicating a strengthening of environmental law enforcement by the government.

Table 7. Mechanism of environmental regulation.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Er	Punish	er	Punish	er	Punish
<i>legal</i>	0.0814 *	0.0313 **	0.1424 **	0.1574 **	0.0574 **	0.0678 **
	(0.0456)	(0.0159)	(0.0678)	(0.0623)	(0.0292)	(0.0278)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Province × year-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Sample city	all cities	all cities	pilot cities	pilot cities	Neighbouring cities of pilot city	Neighbouring cities of pilot city
observations	4845	3990	2856	2352	1870	1540
Adjusted R ²	0.6214	0.6427	0.5783	0.6014	0.5892	0.6424

Notes: standard errors in parentheses. * $p < 0.10$; ** $p < 0.05$.

Second, we aim to investigate the influence of the environmental court on public engagement in environmental protection. Following the method above, the dependent variables are substituted with two indicators: the number of petition letters on environmental issues per ten thousand yuan of industrial output value (evnum) and the number of on-site visits by the public to the government due to environmental issues per ten thousand yuan of industrial output value (pubnum). The regression model incorporates control variables such as population size, GDP per capita, the proportion of gross industrial product in total output value, and the provincial time effect. Due to data constraints, the number of petition letters and visits were sourced from provincial data in the China Environment Yearbook. Given that the explained variable in this paper primarily pertains to industrial pollutants, which are directly correlated with the industrial scale of a region, a higher proportion of industrial output in gross regional product would lead to more industrial pollutants, thereby requiring pollution control measures. Therefore, this paper derives a prefecture-level index by multiplying the proportion of a prefecture-level city's gross industrial product in the province's total industrial production by the provincial variable. The results in Table 8 indicate that the establishment of environmental courts improves the level of public participation in environmental protection. The cross-regional management of environmental courts and the residents' increasing awareness of judicial rights protection play essential roles in improving public participation in environmental protection in neighbouring areas.

Table 8. Mechanism of public participation in environmental protection.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Evnum	Pubnum	Evnum	Pubnum	Evnum	Pubnum
<i>legal</i>	0.1354 *	0.0524	0.4137 **	0.1072 **	0.0416 **	0.0114 **
	(0.0704)	(0.0331)	(0.1971)	(0.0543)	(0.0177)	(0.0068)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Province × year-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Sample city	all cities	all cities	pilot cities	pilot cities	Neighbouring cities of pilot city	Neighbouring cities of pilot city
Observations	4845	4845	2856	2856	1870	1870
Adjusted R ²	0.7326	0.7616	0.6573	0.7384	0.7052	0.7622

Notes: standard errors in parentheses. * $p < 0.10$; ** $p < 0.05$.

Finally, this paper examines the influence of the environmental court establishment on environmental governance investment from the viewpoint of firms. Firms play a crucial role in environmental governance and are also the major contributors to pollution. Investigating the influence of the establishment of an environmental court on investment into environmental governance can further reveal the internal mechanism of environmental justice to strengthen pollution control. To account for heterogeneity at the city level and firm level, this paper uses the total expenditure on environmental protection by firms (*ei*) and the proportion of total expenditure on environmental protection by firms in terms of total assets (*eir*) as explained variables. Control variables at both the city and firm levels were added into the regression analysis. City-level variables comprised population size, GDP per capita, the proportion of foreign direct investment in GDP and the urbanization rate. At the firm level, variables included total assets, the total liabilities-to-total assets ratio, shareholding ratio of the top five shareholders, and the return rate on assets. Firm-level data are sourced from a database maintained by Guotai Junan Securities Co. Ltd. (Shanghai, China), covering the period from 2010 to 2022. The regression results in Table 9 reveal that environmental courts will significantly increase firms' environmental protection expenditure, not only in pilot cities but also in the neighbouring areas, due to the policy spillover.

Table 9. Mechanism of firms' investment in environmental governance.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Lnei	eir	Lnei	eir	Lnei	eir
<i>legal</i>	0.2123 **	0.1433 **	0.4251 ***	0.1742 ***	0.0914 **	0.0521 **
	(0.0985)	(0.0721)	(0.1352)	(0.0635)	(0.0465)	(0.0264)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
City-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Province × year-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Sample city	all cities	all cities	pilot cities	pilot cities	Neighbouring cities of pilot city	Neighbouring cities of pilot city
Observations	3705	3705	2184	2184	1430	1430
Adjusted R ²	0.4357	0.4432	0.3657	0.3525	0.3015	0.2819

Notes: standard errors in parentheses. ** $p < 0.05$; *** $p < 0.01$.

6. Conclusions

This paper utilizes a quasi-experiment framework to identify the impact of environmental courts on pollution abatement, considering the proximity effect of policy implementation. We focus on municipal-level samples as the research subjects and employ a

spatial difference-in-differences model to identify the pollution abatement effect of environmental courts in the pilot cities and adjacent cities, as well as exploring heterogeneity and mechanisms. Our results demonstrate that environmental courts have effectively reduced industrial wastewater emissions, sulphur dioxide emissions, and nitrogen oxide emissions. After considering the proximity effect of the policy, the pollution abatement effect of environmental courts is more significant. Environmental courts have a stronger effect on pollution abatement in cities with stronger environmental regulations, higher economic agglomeration, and a higher level of openness. Mechanistically, environmental courts promote the government's environmental supervision and public participation in environmental protection, and expenditure on environmental governance by firms.

The research presented in this paper demonstrates that the implementation of environmental courts, which symbolizes the enhancement of environmental justice, has the potential to transcend the territorial governance model of pollution control. This, in turn, can facilitate the advancement of the overall environmental governance level and improve the local government's enforcement of environmental laws, foster the public's participation in environmental protection, and incentivize firms to enhance their pollution control endeavours. Consequently, it can lead to the establishment of an environmental governance system where the public is an active participant. However, it is crucial to acknowledge that the overall regional pollution control effect of enhanced environmental justice must be reinforced by various measures, such as strengthening environmental law enforcement, promoting urbanization, and deepening reform. Hence, to promote pollution control in the future, it is necessary to deepen the reform of the judicial system and encourage the establishment of cross-regional environmental courts to reduce local obstacles to environmental and resource cases. Additionally, improving the government's environmental law enforcement can form a virtuous circle between administrative law enforcement and environmental justice. It is also essential to promote economic agglomerations and regional economic integration and establish a coordination and cooperation mechanism between regional governments. Continuing to deepen reforms and increase economic openness, while being open and inclusive to all parties' opinions and suggestions, is crucial. Optimizing the processes associated with environmental justice is also necessary to achieve the maximum effect of environmental justice on pollution control.

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Appendix A

Table A1. Definitions of symbols in models.

Symbol	Definiton	Symbol	Definiton
a	Refer to one governmnet	V_2	The expected benefits of government b in not implementing environmental governance policies
b	Refer to the other government	$\bar{V}$	The average revenue of government b
R_a	The decrease in pollutant emissions in the jurisdiction of government a	e_c	Cleaner production technology
R_b	The decrease in pollutant emissions in the jurisdiction of government b	e_d	Less clean production technology
I_a	The increase in pollutant emissions in the jurisdiction of government a	c_c	The production cost of adopting cleaner production technology
I_b	The increase in pollutant emissions in the jurisdiction of government b	c_d	The production cost of adopting less clean production technologies
C_a	The cost of pollution control in the jurisdiction of government a	y	The product demand quantity of local residents
C_b	The cost of pollution control in the jurisdiction of government b	y_l	The quantity of product supply from the local market
n	The probability of government a implementing environmental governance policies	y_n	The quantity of product supply from other markets
m	The probability of government b implementing environmental governance policies	$\phi(\cdot)$	The utility function of local residents benefiting from enterprises
α_1	Coefficient of externality of government a on government b	$h(\cdot)$	The loss function for local residents due to environmental pollution
α_2	Coefficient of externality of government b on government a	π	The probability of enterprises being sued by the public due to environmental infringement
M	The amount of rewards that local governments receive from the central government for environmental governance	R	The total utility of residents
F	The amount of penalties imposed by the central government on local governments for not implementing environmental governance policies	S	The initial wealth of residents
σ	The weight assigned to environmental performance in the government's performance evaluation	p_r	A binary variable indicating whether the enterprise is sued in an environmental court
U_1	The expected benefits of government a in implementing environmental governance policies	$\psi(\cdot)$	The probability that a firm chooses cleaner production technology
U_2	The expected benefits of government a in not implementing environmental governance policies	$\bar{y}_l$	The optimal consumption quantity of residents when the enterprise is not sued in an environmental court
$\bar{U}$	The average revenue of government a	$\underline{y}_l$	The optimal consumption quantity of residents when the enterprise is sued in an environmental court
V_1	The expected benefits of government b in implementing environmental governance policies	γ	The probability of an enterprise choosing cleaner production technology when it is not sued in an environmental court

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