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Pollution Transfer under Intergovernmental Competition: Suppression or Opportunity

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Abstract: In recent years, the Sustainable Development Goals have introduced a "race to the top" mechanism to complement the "race to the bottom" in local governance and have an impact on pollution. This study utilizes the environmentally oriented accreditation of National Civilized Cities as a policy shock and applies the PSM-DID method to identify the pollution-relocation effects among cities triggered by the competition in local governance. The results indicate that environmentally oriented intergovernmental competition leads to the transfer of industrial enterprises to non-accredited cities, resulting in a significant increase in their pollution emissions and industrial pollution intensity. This indicates that the competition in asymmetric local governance will lead to the transfer of pollution to backward regions, which hampers the overall implementation efficiency of national environmental policies. Furthermore, heterogeneity analysis reveals that the impact is more significant for cities in the central and western regions. Being nominated for the National Civilized City accreditation helps to inhibit the influx of polluting enterprises. Cities that are not part of integrated environmental regulatory regions show a more pronounced increase in pollution emissions compared to other cities, indicating that symmetric local government environmental regulations and environmental collaborative governance contribute to restraining pollution transfer.

Keywords: intergovernmental competition; pollution transfer; environmental regulation

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1. Introduction

The protection of the environment and the rational utilization of natural resources are prerequisites and foundations for economic development. According to the "2022 China Ecological Environment Bulletin" [1], 126 cities in China, accounting for 35.7% of the total, do not meet environmental quality standards, representing a 4.13% increase compared to the previous year. The water pollution situation is severe. The proportion of poor and extremely poor groundwater quality reached 66.6%, while sewage discharge continued to rise, and unconventional water pollutants increased rapidly [2]. The environmental governance effectiveness of local governments is still unsatisfactory relative to the inputs. Local governments in China formulate environmental-protection measures based on national environmental standards and local conditions, which is a development strategy tailored to local circumstances. However, there are significant differences in pollution-control measures and outcomes among regions and cities. The asymmetric environmental regulations under intergovernmental competition, while helping to reduce pollution levels in regulated areas, have simultaneously led to the transfer of pollution across regions. The resulting problem is that it not only fails to effectively curb pollution at its core but also weakens the original emission-reduction incentives of polluting enterprises due to reduced emission costs, thereby further undermining the effectiveness of environmental governance.

Previous research has confirmed the existence of "Pollution Havens" [3,4], indicating that the strengthening of environmental regulations increases the probability of pollution enterprises transferring to neighboring areas [5,6], peaking at a distance of 150 km [7].

Some enterprises may even adopt lower-cost and more covert methods to address pollution transfer issues within enterprise groups [8]. However, it is worth noting that previous studies have predominantly examined the issue of pollution transfer within the framework of static regulations set by local governments [9–11], focusing on the characteristics of migration itself and its effects on production efficiency and ecological efficiency [12,13]. The impact of intergovernmental competition has received limited attention in these studies. Furthermore, the consequences of pollution transfer on the recipient areas have been largely overlooked.

This study employs the National Civilized City accreditation in China as an exogenous policy shock to investigate the environmental effects within the context of intergovernmental competition. The PSM-DID (Propensity Score Matching with Difference-in-Differences) method has been employed to identify the transfer of pollution resulting from intergovernmental competition and its impact on the recipient areas. This approach helps alleviate concerns related to self-selection bias and endogeneity issues [14], helping to accurately observe the net effects of environmental policies.

The findings of this study contribute to explaining the phenomenon of intensified pollution in certain regions of China under local governance competition. Moreover, it provides empirical evidence that can be instrumental in formulating effective pollution prevention and control measures in the future.

2. Policy Background and Theoretical Framework

2.1. Policy Background

The National Civilized City (NCC) accreditation, overseen by the Central Committee of Civilization of China, is a comprehensive and esteemed city evaluation program implemented nationwide. The mission of the accreditation is to promote sustainable development, encouraging cities to prioritize environmental objectives while simultaneously pursuing economic development [15]. The NCC accreditation criteria combine indicators of both economic growth and environmental governance and follow an evaluation process that includes annual assessments and a comprehensive evaluation over a three-year period. Participation in this accreditation is voluntary, and as of 2023, a total of 146 prefecture-level cities have obtained accreditation. As achieving this accreditation is considered a prestigious honor that reflects the overall level of social development, the attainment of NCC accreditation has been associated with the promotions of many city leaders over the past decade [16]. Consequently, city officials were highly motivated to utilize legal power and various resources to meet the new criteria.

Since 2008, the accreditation criteria have placed an explicit emphasis on sustainable development through various measures, including ecological environment construction, energy conservation, emission reduction, and compliance rates of pollutant discharge by key industrial enterprises [17]. For candidate cities, adherence to environmental standards is a fundamental prerequisite, and any increase in industrial emissions is strictly prohibited. These cities must prioritize the maintenance or even reduction in pollution-causing enterprises and optimize their industrial structure to qualify for the accreditation [18].

2.2. Theoretical Framework

2.2.1. Governance Competition Strategies among Local Governments

To attract mobile production factors and enhance competitive advantages, local governments often adopt a variety of strategies to engage in extensive competition [19]. “Race-to-the-bottom” (RTB) [20,21] and “Race-to-the-top” (RTT) [22,23] are two groups of theoretical models widely adopted to describe the strategic competition scenarios and socioeconomic outcomes associated [24–26].

In the context of environmental governance, RTB refers to a situation where local governments compete with each other by reducing their environmental regulations [27], enforcement effort [28], or standards [29] in order to attract firms and industries. The primary motivations behind this competition are usually to provide job opportunities, stimulate economic growth, or increase tax revenues [30–32]. However, the RTB approach by local governments can result in a downward spiral where environmental protections are weakened, potentially leading to suboptimal levels of public goods provision [33,34], hence at the expense of environmental sustainability and long-term well-being [35–37].

On the other hand, in an RTT situation, local governments compete with each other to establish and enforce higher standards [38], regulations, and practices related to environmental protection and sustainable development [39]. Regions with more developed economies and undergoing industrial structural transformation tend to engage in RTT to attract high-quality, eco-friendly mobile production factors [40,41].

2.2.2. Firms' Responses to Environmental Regulations

Firms respond to environmental regulations in various ways, depending on factors such as the nature of the regulations, the industry sector, and the specific circumstances of the business [42]. According to Porter effects, firms may adopt adaptive approaches, such as technological innovation and sustainable operational changes, to bring about cost savings and market advantages, and hence overall economic performance in the long run [43–46]. Meanwhile, when facing high environmental compliance costs and technological innovation challenges, firms may adopt passive approaches, such as production reduction or relocation [3,4,47].

Research indicates that environmental compliance costs represent a significant proportion of overall expenses for industrial enterprises, and in some cases, these costs can experience sudden increases [32]. In light of this, it becomes a rational choice for businesses to contemplate relocating to neighboring regions with fewer environmental regulations as a means of swiftly safeguarding their competitive advantage and maintaining profitability in the market [48,49]. This phenomenon is particularly evident within pollution-intensive industries, wherein firms, facing the simultaneous challenges of environmental costs and the need for innovation, opt to relocate from regions characterized by stringent environmental standards [35–37,43,44]. Relocation is a rational decision for businesses [49,50], not only for small enterprises balancing differences in resource endowments and market potential between regions [45], but also for conglomerates that have greater flexibility in response to regulatory differences [29].

The relocation commonly involves a movement from developed regions to developing regions and from economically prosperous regions to underdeveloped regions [43,46]. They can more conveniently transfer some pollution-intensive production processes to regions with lower environmental regulations [51,52], with the transferred production processes often having higher pollution intensity [53]. This further exacerbates the pollution structure of local industries, as stated by Antweiler [54], where the expansion of scale and deterioration of structure are the leading causes of pollution problems.

2.3. Research Hypothesis

The long-term unbalanced regional economic development in China has set the social background for RTB and RTT competition modes among local governments in a variety of economic development stages [55]. Government environmental regulations vary in intensity across different regions, generally showing a heterogeneous distribution with stronger regulations in central urban areas and weaker regulations in peripheral areas [56]. With the establishment of high environmental protection standards through the National Civilized City accreditation, cities that adopt adaptive approaches to environmental regulations, particularly those situated in developed regions of China, are inclined to engage in RTT competition during their pursuit of the accreditation [57,58]. As a result, these cities establish stringent regulations and closely monitor key indicators. Consequently, certain firms and industries with significant pollution levels may be compelled to relocate from these cities [43,59]. Eventually, the accredited cities can achieve economic development with negligible emissions.

On the other hand, cities with less-developed economies strive to achieve rapid economic expansion [60,61]. These cities often have lower demands for environmental protection due to their lower level of socioeconomic development. As a result, they lack the motivation to meet the comprehensive socioeconomic standards set by the accreditation. Instead, cities without accreditation may adopt RTB strategies, competing to attract firms or industries with high pollution levels that have relocated from accredited cities, which have set stringent environmental regulations. Consequently, cities without accreditation may experience exacerbated pollution [62].

Therefore, we set Hypothesis 1 as follows:

Hypothesis 1. *Upon the implementation of stringent environmental protection standards associated with the National Civilized City accreditation, the volume of pollution emissions in Chinese cities without accreditation may increase when compared with cities that have obtained accreditation.*

In line with the aforementioned "push-pull" effect, the relocation of businesses with pollution entails both economic growth and environmental losses in the recipient cities, particularly in cities without accreditation, as examined in this study. Based on the assumption of rationality, local governments are incentivized to continuously reduce environmental standards as long as the pollution damage incurred remains lower than the economic benefits and political interests it brings. Consequently, this leads to the transfer of pollution from regions with higher standards to those with lower standards. Only when the negative environmental impact resulting from business relocation exceeds its benefits do the recipient cities accept no more transfers.

Therefore, we set the Hypothesis 2 as follows:

Hypothesis 2. *Upon the implementation of stringent environmental protection standards associated with the National Civilized City accreditation, the intensity of pollution emissions in Chinese cities without accreditation may increase when compared with cities that have obtained accreditation.*

3. Research Design

3.1. Data Source

The general city data used in this study are obtained from the China City Statistical Yearbook [63]. The lists of accredited cities were obtained from the China Civilization Network [64]. To minimize confounding factors, only prefecture-level cities were included in the sample. This study includes data from the period 2003 to 2018 while excluding the years 2020 to 2022. This exclusion is due to the varying impacts of the COVID-19 pandemic on industrial production, environmental projects, and government work across different regions. Excluding cities with missing variables, the final sample contains 2481 observations from 237 cities in China.

3.2. Empirical Strategy and Estimation Specifications

3.2.1. Difference-in-Differences Model (DID)

The Difference-in-Differences (DID) model is a natural experiment-based causality evaluation method [65,66]. It usually includes a treatment group and a control group under a specific policy intervention, and the policy's effect is captured by the average treatment effect, which helps control the systematic difference between the two groups before and after the policy implementation [67,68]. That is, the DID model can effectively solve the problems of endogeneity and comparability caused by the policy.

In 2008, a significant transformation took place in the National Civilized City (NCC) accreditation criteria, wherein environment indicators were included as key evaluation thresholds. This change marked a departure from previous standards and turned the NCC accreditation into a quasi-natural experiment for assessing policy impact. The intense competition in this accreditation provides a good opportunity to observe pollution-relocation effects among cities without accreditation resulting from intergovernmental competition.

This study defines the treatment group (T) as Chinese cities without NCC accreditation. These cities are subject to pollution-relocation effects due to the enforcement of more stringent environmental criteria by the NCC. Conversely, the control group (C) comprises accredited cities, which are not anticipated to undergo pollution transfers.

Following the approach of relevant studies [69,70], we construct a bidirectional fixed-effects model to mitigate omitted variable bias by accurately capturing individual characteristics and time-varying features. Empirical estimation was performed using the following specification model:

$$\begin{aligned} Y_{it} &= \beta_0 + \beta_1(treat_{i,t} \times post_{i,t}) + \beta_2 lngdp_{i,t} + \beta_3 lnwage_{i.t} + \beta_4 fiscal_{i,t} \\ &+\beta_5 open_{i,t} + \beta_6 lninvest_{i,t} + \beta_7 lndensity_{i,t} + city_i + year_t + \varepsilon_{i,t} \end{aligned} \quad (1)$$

where i and t represent the ith city and tth year, respectively.

The dependent variable, denoted as Y_{it}, represents the pollution emission levels. Specifically, industrial sewage emission is used as a proxy variable [71,72]. As a significant pollutant in industrial production, the level of industrial sewage emissions provides a direct reflection of pollution levels and production conditions of industrial enterprises [73,74]. Unlike emissions of exhaust gases, which can often be reduced through the upgrading of production processes and technological innovations, industries that release sewage face specific challenges in meeting stringent environmental standards, leading to a higher likelihood of relocation [75,76]. Specifically, the logarithm of industrial sewage emissions (*lnsewage*) and the ratio of sewage discharge to GDP (*lnpi_sewage*) are used, respectively, as the dependent variable of empirical estimations (the distribution of *lnsewage* before and after taking the logarithm is shown in Appendix A). Other gas emission indicators were used for robustness checks.

The key variable, *treat* × *post*, captures the pollution effects the unaccredited cities received upon the policy shock. $post_{i,t}$ represents a dummy variable, taking the value of "1" for years after 2008. The key coefficient β_1 measures the average treatment effect of the policy shock. If the coefficient is positive, it indicates an increase in emissions, suggesting the presence of increased pollution effects. Conversely, if the coefficient is negative, it implies a reduction in emissions after the policy implementation.

Among the control variables in Model 1, *lngdp* (logarithm of GDP per capita) reflects the level of economic development; *lnwage* (logarithm of average wage) represents residents' purchasing power, which is associated with the industrial output level. *lndensity* (the logarithm of population density) controls the urban scales, which similarly influence the demand for industrial goods. *open* (the degree of opening to foreign investment) controls the concentration of foreign-funded enterprises, which influences the likelihood of adopting technology upgrading among pollution-intensive industries, and it is measured by the proportion of actual foreign direct investment to GDP. *fiscal* (the fiscal self-sufficiency ratio) controls the level of local environmental governance investment, and it is measured by the ratio of local government budgetary revenue to expenditure. *lninvest* (fixed asset investment) reflects the level of infrastructure construction in cities, which stimulates industrial growth in cities [77–79].

$city_i$ denotes a set of city-specific dummy variables, capturing individual fixed effects to control for unobservable factors that may affect pollution emissions at the city level and do not vary over time. $year_t$ denotes a set of time dummy variable. ε_{it} is the random error term.

Further, parallel trend tests were performed to support the validity of the difference-in-differences model, which relies on the assumption of pre-parallel trends, which implies that the treatment and control groups exhibit similar trends in city characteristics before the policy shock, allowing us to infer the absence of anticipated effects on pollution emissions. Considering that policy effects may have a lag due to the slow adjustment of policy implementation foundations and industrial production, this study follows the approach of Beck et al. [80] to construct the dynamic treatment regression model as follows:

$$\begin{aligned} Y_{it} = \beta_0 + \textstyle\sum_t \beta_1(treat_{i,t} \times Time_{i,t}) + \beta_2 lngdp_{i,t} + \beta_3 lnwage_{i.t} + \beta_4 fiscal_{i,t} + \beta_5 open_{i,t} + \beta_6 lninvest_{i,t} \\ + \beta_7 lndensity_{i,t} + City_i + Year_t + \varepsilon_{i,t} \end{aligned} \tag{2}$$

Here, $treat_{i,t}$ represents a dummy variable indicating whether a city belongs to the treatment group, and $Time_{i,t}$ represents a set of dummy variables denoting the order of years. The policy year, which is set as 2008 in this study, is designated as period 0 in the analysis. Dummy variables for preceding years are labeled as "Pre_1", " Pre_2", and so on, while subsequent years are labeled as "Post_1", " Post_2", and so forth. The remaining parameters of the model remain consistent with the baseline model (Equation (1)).

3.2.2. Propensity Score Matching Method (PSM)

Since NCC accreditation is voluntary, there is a self-selection bias of environmental-regulation impacts due to the endogenously differentiated characters among the cities [14]. To reduce the potential self-selection bias, this study adopts the propensity score matching method (PSM) [81] to mitigate the endogeneity concerns while performing difference-in-differences estimation [82,83].

We conducted propensity score matching after grouping the samples. Propensity scores were calculated using logistic regression, and 1:1 nearest neighbor matching was performed to obtain a matched control group of enterprises (C_p). A further test was conducted to check for the common support assumption. If there are no significant differences (standard deviation less than 10%) between the treatment and control groups in the balance test after matching, it indicates good matching results. After applying Propensity Score Matching (PSM), we obtained the matched samples of the DID model (the treatment group (T) and the matched control group (C_p)) to estimate the impact effects.

4. Empirical Results and Analysis

4.1. Descriptive Statistics

Table 1 presents how the main variables used in the study are defined and denoted, as well as descriptive statistics for the sample, including the number of observations, mean value, and standard errors of main variables. The number of observed samples is 2481, including the treatment group and a control group drawn by matching the samples.

Table 1. Descriptive statistics of variables from 2005 to 2016.

Variable	Description	Mean.	Std. Dev.	Min.	Max.
ln(*sewage*)	logarithm of industrial sewage	8.269	1.090	1.946	11.359
ln(*pi_sewage*)	logarithm of ratio of sewage discharge to GDP	0.009	0.016	0.000	0.351
ln(*output*)	logarithm of total industrial output value	16.082	1.294	11.039	19.172
ln(*employment*)	logarithm of number of employees in industrial enterprises	6.346	1.098	2.303	9.247
ln(*enterprise*)	logarithm of number of industrial enterprises	6.346	1.098	2.303	9.247
treat × *post*	interaction term between individual and time	0.434	0.496	0	1
ln(*gdp*)	logarithm of GDP	15.933	0.941	13.310	19.091
ln(*wage*)	logarithm of average wage of worker	10.334	0.480	8.509	12.678
fiscal	fiscal self-sufficiency	0.453	0.222	0.054	1.541
open	opening degree	22.113	37.215	0.012	671.493
ln(*invest*)	logarithm of total fixed-asset investment	15.328	1.246	9.256	18.404
ln(*density*)	logarithm of population density	15.472	1.076	11.008	18.246
	Obs. Num.	2481			

4.2. Parallel Trend Test

Figure 1 illustrates the dynamic treatment effects graph, which shows the changes in emission levels over time for the treatment and control groups. The graph indicates that prior to period 0 (the policy implementation year), there were no significant differences in emission levels between the treatment and control groups. This observation satisfies the parallel trends assumption, suggesting that the two groups were comparable before the policy intervention. After the policy implementation, the graph demonstrates that policy effects gradually emerge and become stronger over time. This test result suggests a sustained impact of the policy on emission levels.

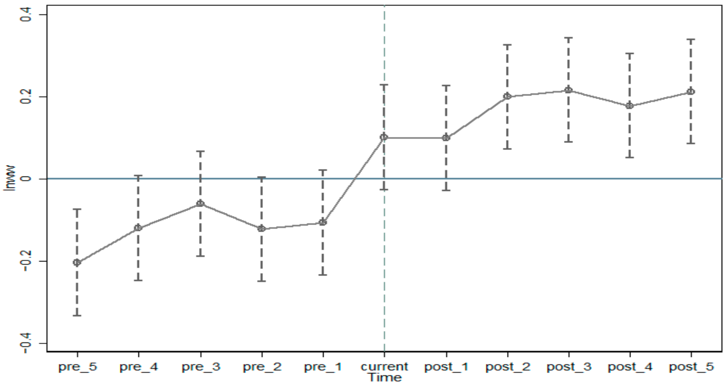

Figure 1. Test of the dynamic effect of pollution-relocation effects. (Notes: the policy year, which is set as 2008 in this study, is designated as period 0 in the analysis. Preceding years are labeled as "Pre_1", " Pre_2", and so on, while subsequent years are labeled as "Post_1", " Post_2", and so forth.).

Table 2 shows that the results of the parallel trend test do not reject the null hypothesis that there were no significant differences in pretreatment trends between the treatment and control groups. Even after policy implementation, the regression coefficients indicate a lagged and fluctuating pattern that is primarily characterized by a gradual increase. The effects reach a peak in the second to third year after policy implementation and maintain a relatively high level, suggesting the long-term and stable nature of the policy effects.

Table 2. Parallel trend test [1].

Variable [2]	Coefficient (S.D.)	Variable	Coefficient (S.D.)
Pre_5	−0.182 (0.070) [3]	Current	0.080 (0.067)
Pre_4	−0.107 (0.071)	Post_1	0.079 (0.067)
Pre_3	−0.056 (0.071)	Post_2	0.242 * (0.226)
Pre_2	−0.105 (0.067)	Post_3	0.199 *** (0.067)
Pre_1	−0.090 (0.067)	Post_4	0.160 ** (0.066)
		Post_5	0.195 *** (0.066)
_Cons	8.654 *** [4] (0.894)		
N	2481		
adj. R^2	0.269		
F	27.76		

Note: [1] While not reported here, the regression estimation has the specification displayed in Equation (2), including all other variables. [2] Dummy variables of years preceding the policy year of 2008 are labeled as "Pre_1" to "Pre_5. "Current" indicates the policy year of 2008. Dummy variables of subsequent years are labeled as "Post_1" to "Post_5". [3] The value of the standard error is in parentheses. [4] *, **, and *** mark significance at the levels of 10%, 5% and 1%, respectively.

4.3. Balance Tests for PSM

Following the steps described in Section 3.2.2, this study groups the samples and first conducts a 1:1 nearest-neighbor matching to obtain a control group of enterprises (C_p) that are well-matched to the treatment group [84]. In order to fulfill the requirements of the common trend hypothesis, we employed the regional dummy variable as the dependent variable and incorporated all aforementioned control variables as independent variables within the framework of the PSM analysis. As presented in Table 3 and Figure 2, the results of balance tests indicate that the standardized differences of variables are significantly reduced after matching and that there are no statistically significant differences between the treatment and control groups. The test results indicate that the propensity score matching (PSM) is performed well.

Table 3. The balance check of PSM.

Variable	Sample	Mean of Treatment Group	Mean of Control Group	Standard Deviation (%)	Decrease in Standard Deviation (%)	T Value	p Value
$\ln(gdp)$	Unmatched	15.932	15.812	−12.6	57.5	3.29	0.001
	Matched	16.023	16.074	−5.3		−0.93	0.351
$\ln(wage)$	Unmatched	10.611	10.055	103.9	92.4	27.09	0.000
	Matched	10.458	10.500	−7.9		1.64	0.102
$fiscal$	Unmatched	0.348	0.519	−87.3	99.2	−23.24	0.000
	Matched	0.431	0.432	−0.7		−0.13	0.896
$open$	Unmatched	21.361	23.958	−6.6	26.5	−1.87	0.062
	Matched	19.118	22.404	−8.4		−1.59	0.113
$\ln(invest)$	Unmatched	15.672	15.095	50.2	86.2	13.06	0.000
	Matched	15.633	15.712	−6.9		−1.28	0.202
$\ln(density)$	Unmatched	5.440	5.802	−40.9	95.2	−11.30	0.000
	Matched	5.677	5.660	2.0		0.35	0.725

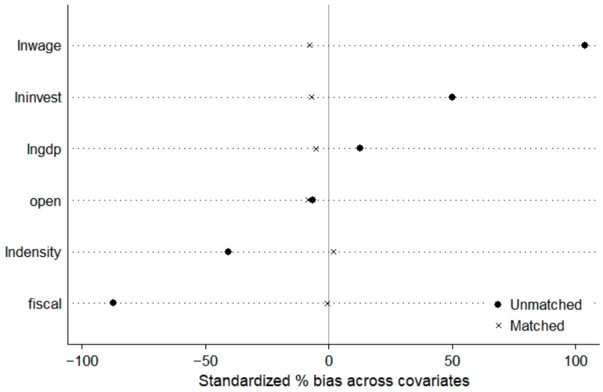

Figure 2. Covariate standardization bias test.

4.4. Regression Results of the Baseline Modle

Table 4 presents the regression analysis results of the baseline model, using the specification outlined in Model 1. In Column (1), the DID model estimates the coefficient of $treat \times post$ to be 0.073, which is statistically significant at the 5% level. In Column (3), the coefficient of $treat \times post$ estimated by the PSM method is 0.093, demonstrating strong significance at the 1% level.

The results suggest that, in the context of the government's environment-oriented governance competition, the treatment group cities have experienced an increase in pollution emissions levels compared to the control group cities. This finding provides support for the hypothesis that the National Civilized City accreditation has led to an increase in pollution emissions as cities compete to meet the stringent environmental criteria.

Using the logarithm of the ratio of emissions to GDP ($lnpi\_sewage$) as the dependent variable, the regressions reported in Columns (2) and (4) in Table 4 were conducted to test the emission intensity. The results yielded similar findings, indicating that the treatment group cities not only experienced an increase in total emissions but also experienced an increase in emission intensity.

Table 4. Baseline regression results of pollution-relocation effects in the intergovernmental competition.

Variable	**DID**		**PSM-DID**	
	ln(*sewage*) **(1)**	**ln(*pi_sewage)*** **(2)**	**ln(*sewage*)** **(3)**	**ln(*pi_sewage*)** [3] **(4)**
Treat × *post*	0.073 ** [1] (0.031) [2]	0.005 *** (0.001)	0.093 *** (0.029)	2.162 *** (0.064)
ln(*gdp*)	0.994 (0.070)	−0.008 *** (0.002)	0.041 (0.070)	−0.907 *** (0.153)
ln(*density*)	−0.194 *** (0.052)	−0.002 (0.002)	−0.169 *** (0.051)	0.203 ** (0.109)
fiscal	0.403 *** (0.119)	0.017 *** (0.004)	0.305 *** (0.113)	1.121 *** (0.245)
open	−0.005 *** (0.005)	0.000 (0.000)	−0.004 *** (0.000)	−0.006 *** (0.001)
ln(*wage*)	−0.221 *** (0.059)	0.003 * (0.002)	−0.071 (0.062)	−0.415 *** (0.135)
ln(*invest*)	−0.041 (0.036)	0.006 *** (0.001)	−0.058 (0.038)	−0.696 *** (0.082)
_Cons	10.589 *** (0.565)	0.199 *** (0.018)	10.307 *** (0.552)	23.8422 *** (1.205)
Year	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes
N	2481	2481	1992	1992
adj. R^2	0.068	0.182	0.064	0.204
F	23.58	2.73	25	3.42

Note: [1] *, **, and *** mark significance at the levels of 10%, 5% and 1%, respectively; [2] The value of the standard error is in parentheses. [3] ln(*pi_sewage*) represents the logarithm of the ratio of sewage emissions to GDP.

The results indicate that intergovernmental environmentally oriented competition indeed had a significant positive impact on pollution emissions in the treatment group cities, leading to an average increase of 0.093 units in the logarithm of sewage discharge. This could be attributed to the relaxation of regulations in unaccredited cities or the relocation of polluting industries. In summary, the lack of cooperative competition among governments has not effectively curbed pollution and may even lead to an overall increase in pollution. This finding partially explains Markusen's discovery, which revealed that non-cooperative environmental policies between governments, as demonstrated by a two-region model, would ultimately lead to a 48% increase in total pollution levels [38].

Considering this with the time trend of the policy (Figure 2), the presence of policy effects is evident, providing evidence for the existence of intergovernmental RTB competition. Over time, the impact of the policy accumulates and becomes apparent, while the interactive competition among governments hampers this policy effect, resulting in a spiral-like upward trend in pollution effects. The findings of this study align with those observed in studies examining government competition among U.S. states. These studies have reported that a 1% change in governance has resulted in regulatory changes of 0.5–1.5% for competing entities [34].

4.5. Robustness Testing

To assess the robustness of the PSM-DID results, this study conducted a placebo test, a test with an extended period, and a test with alternative variables using the baseline model specified in Model 1. These tests were used to evaluate the validity of the estimated treatment effects and to examine whether the observed effects are robust and not driven by other factors.

1. Placebo test. To address the potential issue of spurious regression, two placebo tests were conducted. (1) In line with the literature [85,86], the year 2017, which represents the two years prior to the actual implementation of the policy, was used

as a dummy treatment group in the regression analysis. As shown in Column (1) in Table 5, the regression results obtained after changing the implementation time significantly differed from the baseline regression. These differences suggest that altering the implementation time affected the coefficients of the DID estimator, and they did not pass the significance test. (2) In this test, in line with the literature [87], the treatment group was randomly divided into three equal parts following a normal distribution, as detailed in Appendix B. The results, as presented in Column (2) in Table 5, remained statistically significant, providing further support for the findings of the study. In addition, we further examined the extended sample period.

Table 5. Robustness testing of pollution-relocation effects in the intergovernmental competition.

	Placebo Test		**Extended Period**	**Alternative Variables**	
	Randomly Assigned Sample (1)	**2007 as Policy Year (2)**	**2003–2018 (3)**	**ln(SO_2) [3] (4)**	**ln(Smoke) [3] (5)**
treat × *post*	0.087 (0.033) [2]	0.043 ** [1] (0.021)	0.066 ** (0.030)	0.055 * (0.032)	0.058 * (0.032)
Control	Yes	Yes	Yes	Yes	Yes
_Cons	10.614 *** (0.559)	10.326 *** (0.312)	11.220 *** (0.427)	11.895 *** (0.587)	11.432 *** (0.059)
Year	Yes	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes	Yes
N	2481	2481	Yes	2481	2481
adj. R^2	0.068	0.067	3140	0.049	0.057
F	23.61	23.60	0.132	19.91	20.64

Note: [1] *, **, and *** mark significance at the levels of 10%, 5%, and 1%, respectively; [2] The value of the standard error is in parentheses. [3] ln(SO_2) and ln(smoke) represent the logarithm of SO_2 and industrial smoke.

2. Test with an extended period. In line with Lin [88], this study extended the verification time window from 2003–2013 to 2003–2018, encompassing an additional five years of data. As presented in Column (3) in Table 5, the results remained statistically significant. This approach helps to validate the findings of the study over a longer period and provides additional evidence for the robustness of the results.
3. Test with alternative variables. Sulfur dioxide (SO_2) and industrial smoke (smoke) are also major pollutants emitted by industrial enterprises. In line with the literature [89–91], the logarithm of these two indicators was, respectively, used to replace the dependent variable of Model 1 for regression analysis. The results presented in columns (4) and (5) of Table 5 are consistent with the baseline model, suggesting that the findings are robust across various variable choices and unaffected by variable selection. This further enhances the reliability of the baseline regression results.

5. Further Discussion

5.1. Supporting Evidence of Pollution Transfer

The transfer of production capacity will drive up pollution emissions in the recipient and result in an increased number of enterprises and labor demand [92,93]. To examine the pollution-transfer mechanism, this study further investigates the potential impacts of National Civilized City Accreditation on related economic indicators, such as industrial output, the number of firms, and employment. The estimation was conducted using the baseline regression model (Model 1), with industrial output (*lnoutput*), the number of industrial enterprises (*lnenterprises*), and employment figures of industrial enterprises (*lnemployment*) as the outcome variables, respectively.

In Table 6, Columns (1)–(3), the estimated coefficients of *treat* × *post* are presented, indicating the effects of the policy shock on cities that were not accredited as civilized cities. These coefficients suggest that, following the policy intervention, these cities experienced a greater increase in industrial production compared to accredited cities. This increase in industrial production is associated with the direct transfer of production capacity, which, in turn, leads to pollution relocation. The significant increase in industrial output, the number of enterprises, and labor demand observed in the study provide evidence of this pollution-relocation phenomenon. This finding aligns with the findings by Candau [10], which examined industrial firm relocation among the European Union (EU) countries. Candau found that a 1% increase in interregional government environmental standard differences resulted in a 0.28% increase in industrial firm migration. Our research further indicates that these pollutants flow towards economically less-developed cities through governance competition platforms such as NCC Accreditation.

Table 6. Test on modes and characteristics of pollution transfer.

	ln(Output) [3] **(1)**	**ln(Enterprises)** [3] **(2)**	**ln(Employment)** [3] **(3)**	**IOIS (4)**
treat × *post*	0.071 *** [1]	0.036 **	0.040 ***	−0.007 *
	(0.015) [2]	(0.016)	(0.010)	(0.040)
Control	Yes	Yes	Yes	Yes
_Cons	−2.731 ***	3.006 ***	5.681 ***	1.427 ***
	(0.266)	(0.285)	(0.178)	(0.071)
Year	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes
N	2481	2481	2481	2481
adj. R^2	0.917	0.410	0.149	0.251
F	31.39	48.23	38.56	18.02

Note: [1] *, **, and *** mark significance at the levels of 10%, 5%, and 1%, respectively; [2] The value of the standard error is in parentheses; [3] The indicators ln(output), ln(enterprise), and ln(employment) represent logarithm of the industrial output, number of industrial enterprises, and employment, respectively; IOIS represents the index of industrial structure optimization.

As mentioned in Section 2.2.2, both the scale effect of polluting enterprises and the deterioration of the pollution structure can exacerbate pollution and affect environmental governance [94]. In order to investigate whether the increased pollution emissions in the recipient areas are solely attributable to the scale effect or if there is a deterioration in the pollution structure, this study will examine the pollution characteristics in the recipient areas. Specifically, the study will analyze the industrial enterprise pollution intensity and regional industrial optimization as dependent variables.

By examining the index of industrial structure optimization and the pollution intensity of industrial production in the recipient areas, it will be possible to determine whether the relocated industrial enterprises contribute to a worsening pollution level in the recipient areas. If the index of industrial structure optimization decreases and the pollution intensity of industrial production increases in the recipient areas, it can be concluded that the pollution level of the relocated industrial enterprises is relatively more severe than that of the recipient areas. This exacerbation of pollution in the recipient areas can create a situation commonly referred to as a "pollution haven" [95]. Alternatively, if the relocation of polluting enterprises does not lead to a significant deterioration in the pollution structure of the recipient areas and the observed increase in pollution emissions is primarily attributed to the scale effect, it suggests that the relocated polluters have not substantially worsened the pollution profile of the recipient regions.

Based on this reasoning and following the approach of Xu [96], the index of industrial structure optimization (IOIS) is constructed as below:

$$IOIS = \Sigma\left(I_J \cdot J\right) = I_1 \cdot 1 + I_2 \cdot 2 + I_3 \cdot 3 \tag{3}$$

where I_1, I_2, and I_3 represent the contributions of different sectors, namely, the primary industry, the secondary industry, and the tertiary industry, respectively, while J represents the proportion of industrial value added to GDP. The index typically ranges between 1 and 3, with lower values indicating lower levels of industrial structural optimization and higher values representing a more optimized and diversified industrial structure. The IOIS provides valuable insights into the development and performance of an economy's industrial sector.

The findings presented in Column (4) of Table 6 indicate a decrease in the index of IOIS, coupled with increases in total pollution and urban industrial emission intensity. This suggests a deterioration in the industrial pollution structure within the recipient areas. This finding aligns with prior research conducted on industrial enterprises in 28 OECD countries [43], although the impact coefficient is not substantial. Even though the recipient areas have not yet obtained national civilized city accreditation, they often adopt a cautious approach towards hosting highly polluting enterprises. This cautious attitude acts as a control mechanism, preventing a significant deterioration in the local pollution structure and resulting in a "Not-in-my-backyard" outcome [62].

5.2. Heterogeneity Analysis

5.2.1. Nomination of National Civilized Cities

The possibility of being nominated as candidates for National Civilized Cities can incentivize these cities to adopt environmental regulations that promote RTT, even if they do not eventually attain the accreditation. Given the significant incentives provided by National Civilized Cities for stimulating economic development and political advancement, certain cities allocate significant amounts of resources to pursue this honor, even without having obtained the accreditation. Nominations are granted to cities based on their higher comprehensive scores or good performance in environmental policy implementation [64], which indicates the adoption of symmetric environmental regulations in response to policy impacts. Building on this premise, this study divides the sample cities into two groups, nominated cities and non-nominated cities, to perform further regression analysis, and an RTT strategy is adopted.

The findings presented in Columns (1) and (2) of Table 7 highlight a notable heterogeneity between the nominated cities and the non-nominated cities. Specifically, the emission levels of non-nominated cities have exhibited an upward trend throughout the accreditation process. This finding aligns with previous research [97], supporting the notion that the symmetric regulatory environment plays a role in mitigating the pollution crowding-out effect of intergovernmental competition.

Table 7. Heterogeneity analysis.

	Symmetric Regulations		**Location Differences**			**Regional Integration**	
Variables	**Nominated Sample [3] (1)**	**Non-Nominated Sample (2)**	**Western Region [4] (3)**	**Central Region (4)**	**Eastern Region (5)**	**Yangtze River Economic Belt City [5] (6)**	**Non-Yangtze River Economic Belt City (7)**
treat × *post*	0.078	0.120 ** [1]	0.154 *	0.174 **	0.045	0.158	0.113 **
	(0.123) [2]	(0.053)	(0.105)	(0.069)	(0.081)	(0.097)	(0.056)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_Cons	5.880 *	11.112 ***	12.565 ***	9.215 ***	7.155 ***	9.275 **	10.615 ***
	(3.044)	(0.907)	(1.617)	(1.596)	(2.324)	(4.321)	(0.951)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N of obs	251	1345	516	490	590	303	1293
R^2	0.129	0.085	0.122	0.071	0.094	0.088	0.085
F	20.91	19.52	23.54	22.39	10.55	13.28	20.24

Note: [1] *, **, and *** mark significance at the level of 10%, 5%, and 1%, respectively; [2] The value of the standard error is in parentheses. [3] According to the published list of nominated cities for the "Civilized City" title by the Civilized Commission in various years, if a city has been nominated, it is considered to have performed well in environmental policy implementation. [4] Conversely, environmental performance is not good. The regional division follows the standards of the National Bureau of Statistics, and cities in the three northeastern provinces are classified as part of the eastern region. [5] According to the Development Plan Outline for the Yangtze River Economic Belt in 2016, we will proceed with the delineation.

5.2.2. Impact of Location Differences

To account for potential regional disparities that may influence the participation and acceptance of polluting enterprise relocation due to intergovernmental competition, this study takes a further step by dividing the sample cities into three regions: eastern, central, and western regions of China. This classification is based on the criteria established by the National Bureau of Statistics.

The regression results shown in Columns (3)–(5) of Table 7 show significant differences among cities in the western, central, and eastern regions. This indicates that pollution emissions in the central and western regions increased after the start of the environmentally oriented accreditation process, which is consistent with previous research findings [98], with the increase being more pronounced in the central region. This is closely related to the regional distribution of accredited National Civilized Cities. Due to its coastal location and convenient transportation, the eastern region has unique advantages in attracting mobile factors of production compared to the central and western regions. In the eastern region, with the highest density of accredited cities, polluting enterprises have fewer options for relocation to neighboring areas, while the vast central and western regions still have available space. This is likely to make the water environment and public health in western provinces more vulnerable.

5.2.3. Impact of Regional Integration Development

In the next step, this study categorizes the sample cities based on their location within or outside the Yangtze River Economic Belt, which is a significant economic development zone in China known for its strong economic vitality and influence. With its large economic scale, the region has been actively promoting ecological civilization and enhancing water resource protection. The leadership and policy efforts of the central government are expected to have a restraining effect on the extent of pollution transfer.

The regression results presented in Columns (6) and (7) of Table 7 reveal significant heterogeneity between cities in the Yangtze River Economic Belt and other cities within the treatment group. Notably, the impact of environmentally oriented intergovernmental competition is more pronounced among the other cities. These findings suggest that integrated environmental regulation can effectively reduce pollutant emissions and restrict the mobility of polluting enterprises. The comprehensive implementation of the Yangtze River Economic Belt development strategy and the accelerated promotion of ecological civilization construction have facilitated regionally coordinated and integrated environmental regulations. This approach has demonstrated clear advantages in controlling pollution flows between regions, thereby enhancing the effectiveness of environmental policies and their positive effects.

6. Conclusion and Policy Implications

This study employs the PSM-DID method to examine the pollution-relocation effects of intergovernmental competition. The results indicate: (1) The accreditation of NCC, which promotes intergovernmental competition, leads to the regional transfer of pollution. (2) The pollution effect is manifested not only in the scale but also in the deterioration of pollution structure. (3) Receiving a nomination, however, significantly weakens the pollution effect, with the impact on eastern cities notably weaker than in the central and western regions. Integrated environmental regulation can effectively suppress the transfer of polluting enterprises.

The results indicate that the complex competition between governments undermines the expected effectiveness of environmental regulations and hinders the promotion of green innovation. Therefore, timely adjustments to relevant policies and supporting measures are necessary, including the following objectives: (1) Continuously promote the accreditation of NCC, strictly adhere to the accreditation procedures, and increase the number of nominations for NCC to stimulate RTT competition. (2) Take measures to guide green investments and industrial layouts in the central and western regions, strengthen environmental management, and strictly enforce the Environmental Protection Law. Additionally, enhance the corporate environmental credit system and link them with administrative permits, public procurement, financial support, qualification assessments, and subsidy disbursements. (3) Cross-regional environmental protection cooperation mechanisms should be established; unified environmental standards, monitoring systems, and data platforms will help eliminate competitive pollution transfers between regions.

Despite providing valuable findings and implications for governments, this research has limitations. Firstly, the focus on accrediting civilized cities as a policy shock enables observing the impact of environmentally oriented government competition on businesses and the environment, which holds significant implications for urban governance in China; however, this requires careful consideration of the unique policy context when guiding practices in other countries. Secondly, although PSM-DID can help mitigate estimation bias, there is still a need for further refinement of the assumptions within the research design.

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Appendix A

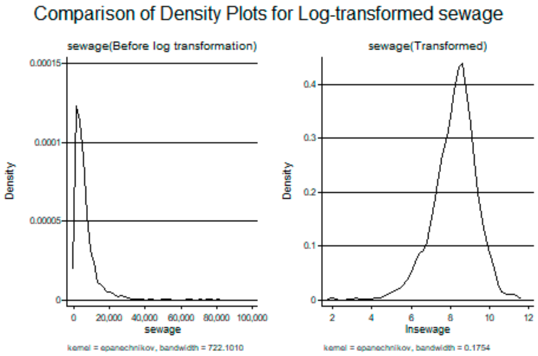

Figure A1. Comparison of density plots for log-transformed sewage.

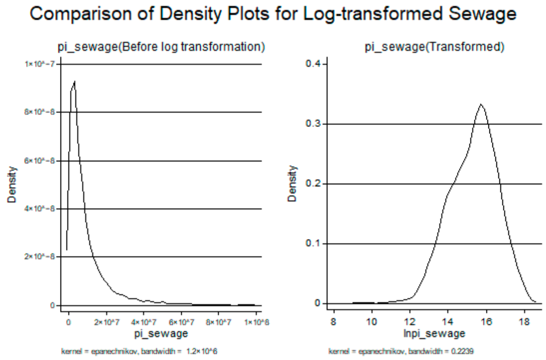

Figure A2. Comparison of density plots for log-transformed pi_sewage.

Appendix B

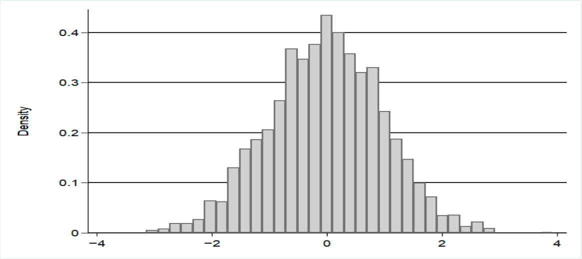

Figure A3. Normal randomization.

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