Can the Establishment of Free Trade Zones Improve Environmental Pollution? — A Perspective from the Beijing-Tianjin-Hebei Free Trade Zone

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Abstract. As China deepens its foreign trade, an important question arises: How can high-level opening up coexist with high-quality economic development while mitigating environmental pollution? This study examines the impact of Free Trade Zone (FTZ) establishment on environmental pollution in the Beijing-Tianjin-Hebei (Jingjinji) region from 2012 to 2022. Using a sample of five research cities within Jingjinji and five control cities from Inner Mongolia and Guizhou, we apply the multi-period difference-in-differences (DID) method and the double fixed-effects model. Our findings indicate that the establishment ofFTZs in the Jingjinji region has a certain inhibitory effect on environmental pollution. The conclusions drawn from this study have significant implications for understanding how FTZ policies can mitigate regional environmental pollution. They also highlight the importance of coordinating financial, environmental, and governmental policies. This research provides valuable insights and effective support for promoting green development and energy conservation across the country as more FTZs are established, emphasizing the importance of balanced development in achieving high-quality economic growth.

Keywords: Free Trade Zone; Environmental Pollution; High-Quality Economic Development; Multi-period Difference-in-Differences Method

1 Introduction

In 2013, the China (Shanghai) Pilot Free Trade Zone began operations as the nation's first free trade zone. In the same year, the Third Plenary Session of the 18th Central Committee of the Communist Party of China issued the Decision of the Central Committee of the Communist Party of China on Several Major Issues Concerning Comprehensively Deepening Reform, adhering to the implementation of a deeper level of opening-up policy [1]. To date, the construction of China's free trade zones (FTZs) has exceeded ten years, with each FTZ firmly implementing the deployment of the

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Central Committee of the Party, making significant contributions to high-quality economic development[2]. In 2015, the Tianjin FTZ was established; in 2019, the Hebei FTZ was established; and in 2020, the Beijing FTZ was established, thus preliminarily forming the Beijing-Tianjin-Hebei (Jingjinji) Free Trade Zone. In December 2023, the three regions of Jingjinji jointly signed the "Action Plan for Coordinated Development of the Jingjinji Free Trade Zone" in Xiongan New Area, implementing five major actions to promote high-level development, high-quality development, and coordinated development of the Jingjinji FTZ [3]. The 20th National Congress of the Communist Party of China emphasized the need to strengthen ecological environmental protection, adhering to the concept that lucid waters and lush mountains are invaluable assets. High-level opening-up and environmental protection are complementary and indispensable [4]. In the field of ecology, the three regions of Jingjinji have jointly established an ecological coordination mechanism, driving the ecological environment of Jingjinji towards green and deepened development[5].

The relationship between free trade zones (FTZs) and environmental pollution initially stemmed from the impact of the North American Free Trade Agreement (NAFTA) on the environment [6]. Empirical studies have shown that the impact of trade on the environment depends on the combined effects of scale, composition, and technology. This conclusion provided a critical analytical foundation for subsequent research on the mechanisms linking trade and the environment. In 2022, another scholar added spatial heterogeneity and mechanisms of action [7], noting that the degree to which FTZ establishment improves environmental pollution varies depending on the radius of study. In summary, although there is still some debate about the use of effects and the frameworks used in studying the relationship between FTZs and environmental pollution, a large body of research indicates that FTZs have a certain inhibitory effect on environmental pollution.

2 Variable Selection and Model Construction

2.1 Variable Selection

This study uses various environmental pollution indicators to measure the environmental pollution index in the Beijing-Tianjin-Hebei (Jingjinji) region. These include industrial sulfur dioxide emissions (tons) (SO2), industrial smoke and dust emissions (tons) (SMOKE), industrial nitrogen oxides emissions (tons) (NOX), and the Environmental Pollution Index (EPI). These variables serve as the dependent variables in our analysis. We use data from 2012 to 2022 for five research cities (Beijing, Tianjin, Shijiazhuang, Baoding, Tangshan) and five control cities (Hohhot, Baotou, Wuhai, Guiyang, Liupanshui) with the same time frame. Missing values in the dataset are imputed using interpolation methods.

The establishment of the Free Trade Zone (FTZ) is the core independent variable. In the study cities, Tianjin was the first to establish an FTZ, followed by Shijiazhuang, Tangshan, and Baoding, which were approved in August 2019, and Beijing, which established its FTZ in August 2020. Due to the temporal differences in the establishment ofFTZs, the timing of the policy impact will vary among the cities. Therefore, we deviate from the traditional difference-in-differences (DID) approach by setting the DID term as the interaction between the policy implementation dummy and the group dummy. A binary variable, DID, is used to indicate whether a city has been designated as an FTZ, where DID = 1 if the city was designated as an FTZ in a given year, and DID = 0 otherwise.

The development of FTZs is influenced by various factors. Based on previous literature, the following variables are selected as control variables:(1) Regional economic development level (LN_GDP_PER): Measured by the logarithm of per capita regional GDP (yuan). (2) Population size (LN_POP): Measured by the logarithm of the registered population (ten thousand people). (3) Regional technological development level (LN_SRIE): Measured by the logarithm of scientific research expenditures (ten thousand yuan).

2.2 Data Sources

The data used in this study cover the period from 2012 to 2022 for ten cities. Given the small number of missing data points, we use interpolation to fill in the gaps. The original data primarily comes from the China Urban Statistical Yearbook, the China Research Data Service Platform (CNRDS), and the Guotai An CSMAR database. Additional data is supplemented through local statistical yearbooks of provinces and municipalities.

2.3 Model Construction

We treat the establishment of the Free Trade Zone (FTZ) as a quasi-natural experiment. Cities are divided into two groups: experimental and control groups based on whether they have established an FTZ. Cities that have established an FTZ are considered the experimental group, while those without an FTZ are the control group [8]. We designate the five cities with FTZs as the experimental group and the remaining five cities without FTZs as the control group. Firstly, we conduct F-tests and Hausman tests on the data. The results of these tests are as follows in Table 1 and Table 2.

Table 1. F-test

SO2	*Coef.*	*St. Err.*	*t-value*	*p-value*	*[95% Conf*	*Interval]*	*Sig*
smoke	-0.151	0.086	-1.76	0.079	-0.32	.017	*
nox	1.196	0.155	7.70	0	0.892	1.501	***
o	0	.	.	.	.	.	
did	-27654.2	13397.84	-2.06	0.039	-53913.5	-1394.944	**
gdpper	-0.028	0.155	-0.18	0.855	-0.333	.276	
pop	-40.986	20.758	-1.97	0.048	-81.672	-.3	**
srie	0.005	0.008	0.58	0.561	-0.011	.02	
Mean dependent var		68343.409		SD dependent var		74639.84	
Overall r-squared		0.681		Number of obs		71347.818	
Chi-square		219.988		Prob > chi2		110	
R-squared within		0.635		R-squared between		0.000	

Table 2. Hausman test

	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	Std. err.
smoke	-0.8055172	-0.1512478	-0.6542694	0.1143956
nox	-0.9764624	1.196491	-2.172953	0.2793826
did	-3.437043	-27654.22	27650.79	7153.876
gdpper	3.78E-05	-0.02841	0.028451	0.045896
pop	0.006681	-40.9858	40.99252	6.819495
srie	-4.98E-06	0.004674	-0.00468	0.001765

b = Consistent under H0 and Ha; obtained from **xtreg.**
B = Inconsistent under Ha, efficient under H0; obtained from **xtreg.**
Test of H0: Difference in coefficients not systematic
chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
=**78.66**
Prob > chi2 =**0.0000**

Their p-values are all less than 0.05, and all two tests pass, so we use the fixed-effects model:

$$Yit = \beta 0+\beta 1DIDit+\beta 2Xit+\gamma i+\epsilon \quad (1)$$

Where y_{it} represents the explanatory variables, i.e., industrial sulphur dioxide emissions (tonnes) (SO_2), industrial soot emissions (tonnes) (smoke), industrial nitrogen oxides emissions (tonnes) (NO_X), and Environmental Pollution Index (EPI), and i denotes the city, and t denotes the time [9]. DID_{it} is the core explanatory variable, i.e., the FTZ dummy variable, which is recorded as DIDit= 1 if city i has set up an FTZ at time t, and 0 otherwise. x_{it} is a vector of control variables, including the logarithm of per capita regional gross domestic product (yuan) (gdpper), the logarithm of the household population (10,000) (pop),and the logarithm of science expenditure (million yuan) (srie). β_0 is the intercept term, which is the coefficient of DID, and β_1 denotes the effect of the establishment of the FTA on environmental pollution. β_2 is the vector of coefficients for the control variables. y_i is the city fixed effect, which controls for city-specific factors that do not change over time. E_i is the error term.

3 Analysis of Empirical Results

3.1 Parallel Trend Test

In this paper, a multi-period double-difference model (DID) is used to empirically examine the impact of the establishment of the Beijing-Tianjin-Hebei Free Trade Zone on environmental pollution [10]. An important prerequisite for constructing a multi-period DID model for the empirical analysis is that the sample data must pass the parallel trend hypothesis test, i.e., the overall development trend of the sample data before the implementation of the policy is consistent.

The treatment variable $treat_{ct}$ is interacted with a series of time dummy variables and the following equation is constructed to examine whether the parallel trend test is passed:

$$TFP_{ft} = \beta_0 + \sum_{j(j\neq-1)}^{-6,6} \alpha_i\, treat_{ct} \times time_c^j + X_{fct}\gamma + \rho_f + \rho_t + \varepsilon_{it} \tag{2}$$

Where: $treat_{ct}$ is a dummy variable used to indicate whether the city establishes an FTZ within 2012-2022, and the value of this variable is equal to 1 if the FTZ is established or already exists in period t, otherwise it is equal to 0; and $treat_{ct}$ is used to indicate the time when the city establishes an FTZ.

The results of the parallel trend test are displayed in Figure 1, with the dashed line indicating the 95 per cent confidence interval and the dots indicating the regression coefficients of the time dummy variable DID, with the previous period of policy implementation as the base period.

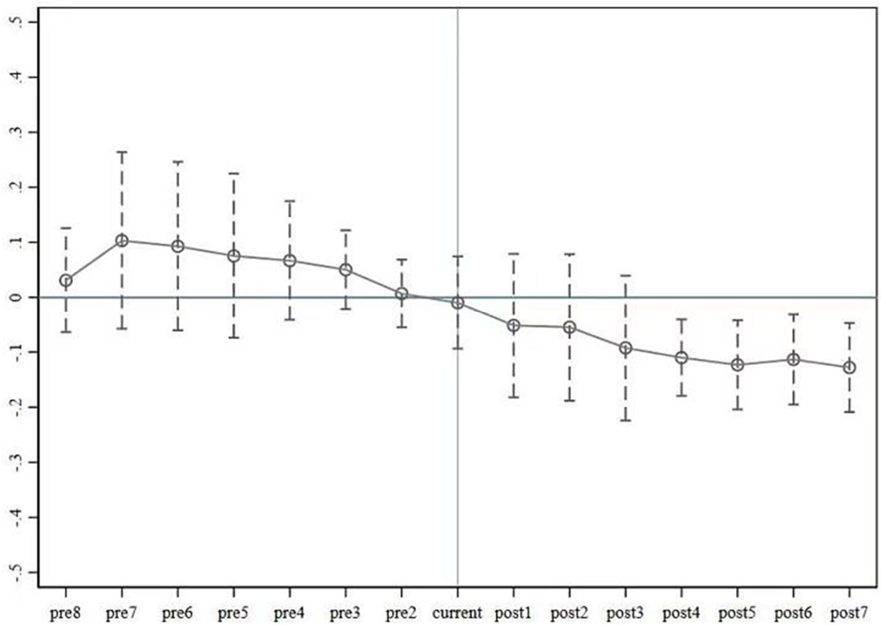

Fig. 1. Parallel trend test

As can be seen from Figure 1, the impact effect produced before the policy implementation point 0 is not significant, the sample data successfully passed the parallel trend hypothesis test; from the policy implementation period to the policy implementation of the 7th period, the policy implementation dummy variable on the explanatory variables produced a negative impact on the overall fluctuations in the increasing trend of the overall trend, from the 4th period onwards the FTZ test to the degree of significant impact on the environmental pollution, the FTZ test. From this, it can be concluded that the effect of the FTZ test policy on environmental pollution has a lag. In summary, the conclusion that the establishment of the Beijing-Tianjin-Hebei FTZ has a negative impact on environmental pollution (mitigating effect) is somewhat robust.

3.2 Placebo Test

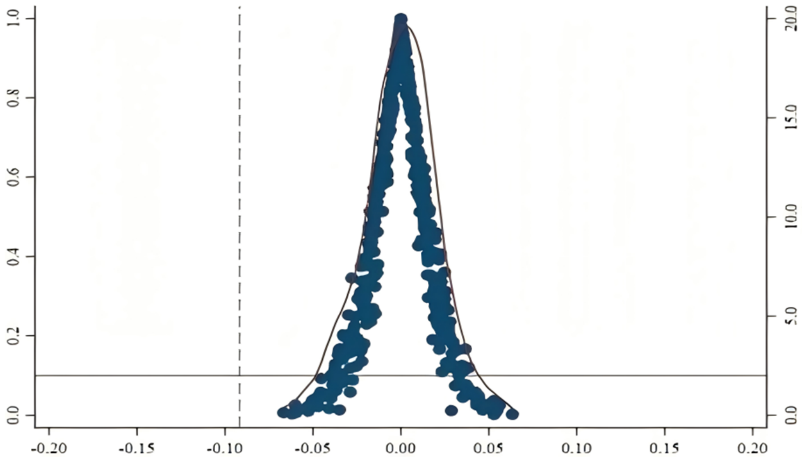

Fig. 2. Placebo test

Studying the impact of the establishment ofFTZ in Beijing-Tianjin-Hebei region through double difference estimation method, it is inevitable to encounter certain uncontrollable or unobservable factors that will bias the estimation results, and this paper deals with this problem through placebo test. Policy shocks are randomly generated to produce an estimated coefficient, and then the above process is repeated 1000 times to obtain the estimated coefficients and corresponding P-values of the FTZ DID, and the results are shown in Figure 2.

It can be found that most of the coefficients of the core explanatory variables DID are distributed near zero and are not significant, and the P value is greater than 0.1 and obeys a normal distribution, so the impact of the establishment of Beijing-Tianjin-Hebei FTZ on environmental pollution in our study has not been affected by the problem of the omitted variable factor.

3.3 Robustness Test

According to the results in Table 3, the coefficient of the establishment of the FTA (did) is always negative in all models indicating that the existence of the Beijing-Tianjin-Hebei FTA is significantly associated with a reduction in the level of environmental pollution. With the increase of control variables in the model, the size of the absolute value of the coefficient of the FTZ test changes, but remains negative [11]. This suggests that the effect of the establishment of the Beijing-Tianjin-Hebei FTZ on environmental pollution is negative (i.e., the establishment of the

Beijing-Tianjin-Hebei FTZ has a mitigating effect on environmental pollution), and that this effect remains robust after controlling for multilevel fixed effects.

Table 3. Robustness testing

	(1)	(2)	(3)	(4)
	so2	*smoke*	*nox*	*EPI*
did	-1.41e+04	-3.66e+04	-1.49e+04	-0.054
	(-1.029)	(-1.417)	(-1.042)	(-1.338)
lngdpper	64740. 160***	1.48e+05***	81513.042***	0.244***
	(5. 125)	(6.231)	(6.205)	(6.595)
lnpop	50318.961***	1.08e+05***	75728.405***	0. 195***
	(5.578)	(6.387)	(8.073)	(7.413)
lnsrie	-3.33e+04***	-6.91e+04***	-4.04e+04***	-0. 119***
	(-6.058)	(-6.674)	(-7.053)	(-7.375)
cons	-5.77e+05***	-1.45e+06***	-8.51e+05***	-2.391***
	(-4.240)	(-5.677)	(-6.019)	(-6.015)
N	107	107	107	107
R^2	0.296	0.354	0.429	0.403
Fstat				

***p<0.01, **p<0.05, *p<0.10

4 Conclusions

This study utilized urban data from 10 prefecture-level cities from 2012 to 2022, with Beijing, Tianjin, Shijiazhuang, Baoding, and Tangshan serving as the experimental group and Hohhot, Baotou, Wuhai, Guiyang, and Liupanshui as the control group. Through a fixed-effects model, we analyzed the impact of the establishment of the Jingjinji Free Trade Zone on environmental pollution. The findings show that the establishment of the Jingjinji Free Trade Zone has a certain inhibitory effect on environmental pollution. After considering the parallel trends test, placebo tests, and conducting robustness checks, the conclusion remains valid. Correlation and regression analyses indicate a negative correlation (i.e., inhibitory effect) between the establishment of the Jingjinji Free Trade Zone and environmental pollution. In the heterogeneity analysis, although the magnitude and significance of the impact on different dependent variables vary, all exhibit a negative effect, further suggesting a positive association between the establishment of the Jingjinji Free Trade Zone and the inhibition of environmental pollution. In summary, this study confirms that the Jingjinji Free Trade Zone has played a certain inhibitory role in environmental pollution.

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