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Review Article

The Effectiveness of Environmental Policy Mix: Evidence from the Zhejiang Sewage Treatment Policy

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The development of more effective environmental policies is a common concern among scholars, government and the public. This paper attempts to investigate whether the environmental policy mix can really work. Taking the "Five Water Co-Treatment" policy of Zhejiang Province as an example, we applied the synthetic control method to examine the impact of multi-objective environmental policies on industrial sewage discharge and urban sewage discharge in Zhejiang. Further, we analyzed the effect of industrial value added and the length of water pipelines on sewage discharge and examined the potential environmental Kuznets curve (EKC) relationships. Our results of synthetic control imply that the "Five Water Co-Treatment" policy has increased the industrial and urban sewage discharge. However, the results of the extended analysis show that this is a process of standardizing sewage discharge and an embodiment of enhanced sewage treatment capacity. Therefore, we believe that the "Five Water Co-Treatment" policy is effective and should continue to advance.

1. Introduction

In recent years, the situation of water environment in China has become more and more serious [1]. More than 61% of groundwater and 28% of surface waters in the main river basins classified as unfit for human use or contact [2]. The development of water pollution has spread from urban to rural areas, including pollution sources such as domestic pollution, nonpoint source pollution and industrial and mining pollutions. At the same time, since most of the water sources and reservoirs in large cities are located in the surrounding suburban towns and rural areas, water pollution in rural areas has caused potential safety risks in drinking water.

According to the 2013 Zhejiang Provincial Water Conservancy Bulletin, the per capita water resources in Zhejiang Province is only 1760 cubic meters, which has nearly reached the world's recognized 1700 cubic meters warning line. Although Zhejiang's water resources per unit area can be ranked fourth in China, since 80 percent of water resources are distributed in mountainous areas, Zhejiang Province, where population is concentrated and economically developed, is a key water-deficient area. Moreover, water resources in Zhejiang still have four major problems, such as large gaps in supply and demand, prominent structural contradictions, serious pollution, and low effective utilization.

In order to alleviate the shortage of water resources and pollution, Zhejiang province introduced the "Five Water Co-Treatment" policy in 2014, which refers to the five measures of treating sewage, preventing floods, draining water, ensuring water supply, and saving water. From an economic point of view, the Zhejiang Provincial Government believes that water control is an effective way to promote investment and economic transformation. The investment in water control is an effective investment in itself. And the process of water management is considered to be the process of economic transformation. In the past few years, due to the decline in willingness of private investment, difficulty in introducing high-quality foreign capital, and limitation of government investment, good investment projects are crucial to maintaining effective investment growth. Water control can provide a large number of high-quality projects for the people, especially water conservancy projects, which is of practical significance for maintaining stable economic growth. From the ecological point of view, the essential goal of this water control policy is to optimize the ecological environment to allow the ecosystem services and survival of biological communities [3–5]. Although the reasons for "water shortage" in Zhejiang include the restriction of resource shortage in island areas and engineering shortage in some mountainous areas, the main reason is water shortage caused by pollution. The root cause of water shortage is the extensive growth mode that relies too much on resource and environment consumption.

It has been the fifth year since the implementation of the "Five Water Co-Treatment" policy. From the details of the implementation, we found that the focus of the policy is to deal with urban flooding problems and water pollution. Therefore, during the period from 2014 to 2018, many water control projects were carried out in Zhejiang province, such as dam repair and construction, dredging rivers, and construction of sewage treatment plants. However, the prevention of the sources of water pollution, such as industrial sewage discharge and urban sewage discharge, have not received sufficient attention.

Therefore, it is important to investigate whether this water control policy is really working. In order to explore the true utility of the "Five Water Co-Treatment" policy, we designed a quasi-natural experiment on industrial sewage discharge and urban sewage discharge in Zhejiang province based on the synthetic control method developed by Alberto et al. [6]. The synthetic control method compensates for the defects of other quasi-natural experiments (such as difference-in-difference, or DID, etc.) and fully considers the particularity of the treatment group. By constructing a "counter-factual" reference group by weighted average of other provinces, the gap between real sewage discharge and counter-factual sewage discharge is the effect of this policy. Based on a panel dataset of 12 provinces in eastern China from 2000 to 2017, after controlling for industrial added value, number of industrial enterprises, urban sewage treatment rate, length of urban water supply pipelines and length of urban drainage pipelines, we evaluated the final results of the "Five Water Co-Treatment" policy and adopted a series of tests. First, following the existing literature, we examined the potential environmental Kuznets curve (EKC) relationship and attempted to interpret the discharge changes of industrial sewage and urban sewage from the perspective of economic development. Then, we explored the effect of pipe length on sewage discharge, and further discovered the real cause of sewage discharge changes and the actual effect of the "Five Water Co-Treatment" policy.

The current study is organized as follows. Section 2 is a review of the related literature. The mechanism derivation of the synthetic control method and the selection of the control group are discussed in Section 3. Section 4 describes the data and variables used in this article. Section 5 reports our empirical model and estimation results. Section 6 is an extended analysis based on the environmental Kuznets curve hypothesis. Section 7 concludes and discusses the implications.

2. Literature Review

The experience of developed countries proves that establishing and implementing a set of environmental economic policies that are compatible with social development is an effective way for government intervention in environmental protection [2, 7]. In recent years, research in environmental economics and sustainable development has been quite active. On the one hand, the development of mainstream economics provides new theoretical tools and analytical methods for environmental economics research. Scholars from various countries have carried out research from different perspectives on environmental property rights, environmental value assessment, economic growth model under environmental constraints, transboundary environmental pollution, the selection and implementation of environmental regulation tools, and trade and environmental issues in the context of globalization. On the other hand, the evolution and development of environmental economics over the past 25 years indicates that with the formulation and implementation of environmental management and sustainable development strategies, policy issues in real demand have provided an important impetus for the development of environmental economics.

The designing of an effective environmental governance policy is an important issue of concern to the academic and policy communities. Economists advocate that market-oriented environmental governance as the most cost-effective means to mitigate the harmful effects of pollution, and is easier to obtain support from residents [8, 9]. However environmental supply exists as a public good, and the government must play a leading role. Specifically, the economic instruments that the government can take include input tax, ambient tax/subsidy, governmental financial assistance, and tradable permits [10]. In this paper, we summarize the existing literature from two dimensions: the methods of evaluating environmental policies and the effectiveness of these policies implementation.

First, in the literature of policy evaluation methods, Jing et al. [11] developed a modified log-linear model to solve the problems with respect to the complex seasonal patterns in terms of both the variation magnitude and period. Smith et al. [2] adopted a conceptual model for the process of lesson drawing and identification of constraints. Then they analyzed the policy challenge of diffuse water pollution from agriculture. By analyzing the trend of air quality index (AQI), Monforte et al. [12] evaluated the air quality in the Mediterranean region and pointed out that such studies could be applied to each region or municipality. Ultimately, the conceptual model for policy transfer is applied to review the potential for an improved policy framework. Jia et al. [13] constructed a management dynamics model, which is the approach of system dynamics and implemented by the Vensim software, to investigate the effect of the air pollution charging fee policy on the haze pollution in China. In Jing et al. [14], data envelopment analysis model was used to evaluate the industrial environmental efficiency in different cities. The PMG/ARDL regression models were used to study the relationship between the migration policy of pollution-intensive industries and environmental efficiency at the prefecture level throughout China's Guangdong Province from 2001 to 2014. Zhang et al. [15] established five policy scenarios, including raw material substitution, eliminating backward small-sized capacities, promoting cleaner technologies, advancing end-of-pipe treatment technologies and the integration of all these

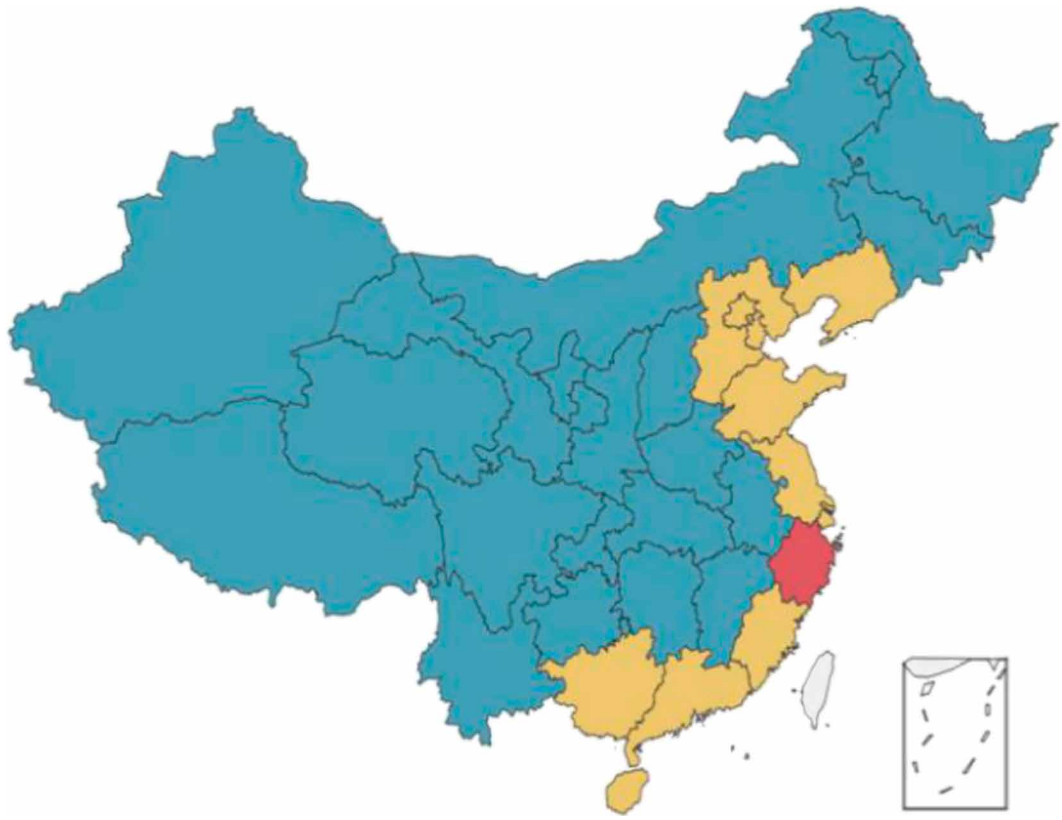

Figure 1: Control group selection.

policies, and developed a technology-based model to assess alternative water pollution reduction policies in the pulp and paper industry up to 2020. Other methods for assessing the effectiveness of policies include: binary Probit models [16], panel data models [17], Box-Jenkins ARIMA models [18], dynamic game models [19], and so on.

Second, in the literature on the practical validity of environmental policies, although some policies such as specific taxations and subsidy policies have proven to be effective, not all policies meet the expected goals [13, 18]. Some policies have not only failed to achieve the desired goals, but have brought a variety of problems. Specifically, the interpretation of noneffective environmental policies includes: (1) Cross-border transfer of pollution. For example, Cai et al. [20] and Wu et al. [21] studied the effects of COD and NH emission reduction requirements in China's "10th Five-Year Plan" and the "11th Five-Year Plan", respectively, and found that water pollution control caused cross-border pollution and its transfer to western China. (2) Discontinuity of pollution control policy implementation. In the analysis of Jing et al. [11], anomalous Ammonia Nitrogen concentrations were found to be linked to failures of discontinuity in implementation of pollution control policies in the transition between two consecutive Five-Year Plans. (3) Inconsistency of multiple policy instruments. Zheng et al. [17] found that the combination of multiple policies did not bring consistent practical results. The implementation of both economic policy instruments and public participation encourages industrial relocation, whereas the implementation of environmental legal policy instruments like laws, regulations and rules prevents polluting industries from relocating to other regions. (4) Heterogeneity of policy implementation. Zheng et al. [17] also found that the effects of the same policy on different objects can generate heterogeneity. In particular, the effect of environmental policies varies with industrial characteristics, and air pollution intensive industry dominated by stated-owned capitals are insensitive to legal policy instruments. The findings of Yang et al. [18] indicate that pollution control policies are more effective in Shanghai, Jiangsu and Zhejiang. However, there are no obvious improvements in air quality in Anhui, and in some other cities there are even deterioration in air quality scores. (5) Division of local government. When examining the spatial behavior of pollution intensive firms across the Taihu Lake Watershed, Yuan et al. [16] found that the effect of strict environmental policies was compromised by the differences in the effectiveness of policy enforcement across the watershed.

Reviewing the above literature, we are convinced that environmental policies, whether single or mixed, are not always effective. At the same time, most of the tests for the implementation of environmental policies have considered the methods of index construction and multiple regression analyses. Few literatures apply quasi-natural experiments to the simulation evaluation of environmental policies. Therefore, this paper will consider the synthetic control method to evaluate the real effect of "Five Water Co-Treatment" on pollution emissions, and further explore its influencing factors based on the evaluation results.

3. Methodology

On May 27, 2014, Zhejiang Province established the "Five Water Co-Treatment" technical service group, representing the formal implementation of this policy. We regard the "Five Water Co-Treatment" policy implementation as a natural experiment for Zhejiang. According to the project evaluation theory, Zhejiang will be the treatment group after 2014, and other provinces will be the control group. By comparing the differences between the treatment group and the control group, we can estimate the impact of "Five Water Co-Treatment" on sewage discharge. An intuitive idea is to use the DID to compare the changes in sewage discharge between Zhejiang and other regions after the implementation of the "Five Water Co-Treatment". The difference between the two can reflect the impact of this policy. However, DID method has two major obstacles in dealing with such problems: (1) The selection of the control group is subjective and arbitrary, not persuasive; (2) The policy is endogenous, and there is a systematic difference between Zhejiang and other provinces, which is exactly the reason why Zhejiang implements "Five Water Co-Treatment".

Synthetic control method overcomes such drawbacks. It can make a proper linear combination of several provinces and municipalities in China, construct a better "synthetic control area", and compare "real Zhejiang" with "synthetic Zhejiang". However, in order to be as similar as possible to Zhejiang in terms of geography and economic development, we select the provinces and municipalities in eastern China as the potential control group. As shown in Figure 1, the remaining 11 eastern provinces and municipalities except Zhejiang are Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Fujian, Shandong, Guangdong, Guangxi, and Hainan. The standardization form of synthetic control method can be written as follows [6].

Suppose that we observe $J+1$ regions. Without loss of generality, suppose also that only the first region is exposed to the intervention of interest, so that we have J remaining regions as potential controls. Also without loss of generality and to simplify notations, we assume that the first region is uninterruptedly exposed to the intervention of interest after some initial intervention period.

Let Y_{it}^N be the sewage discharge that would be observed for region i at time t in the absence of the intervention, for units $i = 1, \ldots, J+1$, and time periods $t = 1, \ldots, T$. Let T_0 be number of pre-intervention periods, with $1 \le T_0 < T$. Let Y_{it}^I be the sewage discharge that would be observed for unit i at time t if unit i is exposed to the intervention in periods T_0+1 to T. Following Alberto et al. (2010), we assume that the intervention has no effect on the sewage discharge before the implementation period, so for $t \in \{1, \ldots, T_0\}$ and all $i \in \{1, \ldots, N\}$, we have that $Y_{it}^I = Y_{it}^N$. Let $\alpha_{it} = Y_{it}^I - Y_{it}^N$ be the effect of the intervention for unit i at time t, if unit i is exposed to the intervention in periods $T_0+1, T_0+1, \ldots, T$ (where $1 \le T_0 < T$). Therefore:

$$Y_{it}^I = \alpha_{it} + Y_{it}^N. \tag{1}$$

Let D_{it} be a dummy variable that takes value one if unit i is exposed to the intervention at time t, and value zero otherwise. The observed outcome for unit i at time t is

$$Y_{it} = Y_{it}^N + \alpha_{it} D_{it}. \tag{2}$$

Because only the first region (region "1") is exposed to the intervention and only after period T_0 (with $1 \le T_0 < T$), we have that:

$$D_{it} = \begin{cases} 1 & i = 1, t > T_0 \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

We aim to estimate $(\alpha_{1T_0+1}, \ldots, \alpha_{1T})$. For $t > T_0$,

$$\alpha_{1t} = Y_{1t}^I - Y_{1t}^N = Y_{1t} - Y_{1t}^N. \tag{4}$$

Because Y_{it}^I is observed, to estimate α_{it} we just need to estimate Y_{it}^N. Suppose that Y_{it}^N is given by a factor model:

$$Y_{it}^N = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{it}, \tag{5}$$

where δ_t is an unknown common factor with constant factor loadings across units, Z_i is a $(r \times 1)$ vector of observed covariates (not affected by the intervention), θ_t is a $(1 \times r)$ vector of unknown parameters, λ_t is an unknown common factor with varying factor loadings, μ_i, across units, and the error terms ε_{it} are unobserved transitory shocks at the regional level with zero mean for all i.

Since sewage discharge may have a time trend in itself, it is important to notice that this model does not rule out the existence of time-varying measured determinants of Y_{it}^N. The vector Z_i may contain pre- and post-intervention values of time-varying variables, as long as they are not affected by the intervention. For example, suppose that, $T = 2, T = 1$, and that Z_{it} is a scalar random variable for $i = 1, \ldots, J+1$ and $t = 1, 2$. Then, if $Z_i = (Z_{i1} \quad Z_{i2})'$, $\theta_1 = (\beta \quad 0)$ and $\theta_2 = (0 \quad \beta)$, we obtain $\theta_t Z_i = Z_{it}\beta$. Notice also that the model in (5) does not restrict Z_i, μ_i, and ε_{it} to be independent.

Consider a $(J \times 1)$ vector of weights $W = \left(w_1, \ldots, w_{J+1}\right)'$ such that $w_j \ge 0$ for $j = 1, \ldots, J+1$ and $w_2 + \cdots + w_{J+1} = 1$. Each particular value of the vector W represents a potential synthetic control, that is, a particular weighted average of the control regions. The value of the outcome variable for each synthetic control indexed by W is:

$$\sum_{j=2}^{J+1} w_j Y_{jt} = \delta_t + \theta_t \sum_{j=2}^{J+1} w_j Z_{jt} + \lambda_t \sum_{j=2}^{J+1} w_j \mu_{jt} + \sum_{j=2}^{J+1} w_j \varepsilon_{jt}. \tag{6}$$

Suppose there is a set of vectors $W^* = \left(w_2^*, \ldots, w_{J+1}^*\right)'$ that satisfy:

$$\begin{gathered} \sum_{j=2}^{J+1} w_j^* Y_{jt} = Y_{11}, \ldots, \sum_{j=2}^{J+1} w_j^* Y_{jT0} = Y_{1T0}, \\ \sum_{j=2}^{J+1} w_j^* Z_j = Z_1. \end{gathered} \tag{7}$$

If $\sum_{t=1}^{T0} \lambda_t' \lambda_t$ is a nonsingular matrix, we can get:

$$\begin{aligned} Y_{it}^N - \sum_{j=2}^{J+1} w_j^* Y_{jt} = {} & \sum_{j=2}^{J+1} w_j^* \sum_{t=1}^{T0} \lambda_t \left(\sum_{t=1}^{T0} \lambda_t' \lambda_t \right) \lambda_t' \left(\varepsilon_{jt} - \varepsilon_{it}\right) \\ & - \sum_{j=2}^{J+1} w_j^* \left(\varepsilon_{jt} - \varepsilon_{it}\right). \end{aligned} \tag{8}$$

Alberto et al. (2010) have proved that, under some general conditions, the right-hand side of the above equation will approach 0. Therefore, for $T_0 < t \le T$, we can use $\sum_{j=2}^{J+1} w_j^* Y_{jt}$

Table 1: Summary statistics.

	Obs	Mean	Std. dev.	Min	Max
ID	216	99270.76	76111.9	717.9	296318
UD	216	198547.7	140773.4	17827	712678
IV	216	8126.197	8053.004	70.46	35291.8
EN	216	49093.44	123357.5	337	669910
ST	207	0.726	0.190	0.317	0.978
SL	216	27146.99	22180.27	1341	103270
DL	216	18057.51	15740.06	1566	76886

Table 2: The weights of the control group.

Province	Unit weight	Province	Unit weight
Beijing	0	Jungian	0
Tianjing	0	Fujian	0.003
Hebei	0.137	Shandong	0
Liaoning	0.038	Guangdong	0.566
Shanghai	0	Guangxi	0.255
Hainan	0		

as an unbiased estimate of Y_{it}^N. Thus $\alpha_{1t} = Y_{it} - \sum_{j=2}^{J+1} w_j^* Y_{jt}$ can be used as an estimate of α_{1t}.

The basic feature of the synthetic control method is to identify the weight of each economy in the control group, that is, each economy constructs a "counter-factual" based on the similarity of its own data characteristics. The degree of similarity between the control group and the treatment group was measured by predictive variables prior to the occurrence of time. Since data-driven procedures reduce discretion in the choice of the comparison control units, forcing researchers to demonstrate the affinities between the affected and unaffected units using observed quantifiable characteristics. Compared with the DID method, it reduces the subjective judgment. Moreover, this method extends the traditional DID method and is a nonparametric method. Further, relative to traditional regression methods, transparency and safeguard against extrapolation are two other attractive characteristics of the synthetic control method [6].

4. Data and Variables

4.1. Data Source and Processing. We used data from four different sources: China Statistical Yearbook, China Environmental Yearbook, China Urban Statistical Yearbook, and the websites of statistics bureaus of the related provinces or cities. For the missing data of a few years, we use the moving average method to interpolate them.

4.2. Variable Description and Summary Statistics. Our goal is to use the weighted average of other provinces and municipalities to simulate the potential Zhejiang sewage discharge without the "Five Water Co-Treatment" policy, and then compare it with the real Zhejiang sewage discharge to estimate the impact of the "Five Water Co-Treatment" policy. According to the idea of synthetic control law, when we choose the weight, we must construct the factors of "synthetic Zhejiang" before the implementation of "Five Water Co-Treatment" and "real Zhejiang" as consistent as possible. The predictive control variables we selected include: industrial value added (*IV*), number of industrial enterprises (*EN*), urban sewage treatment rate (*ST*), urban water supply pipe length (*SL*), and urban drainage pipe length (*DL*). Industrial value added and the number of industrial enterprises largely determine the discharge of industrial sewage. In general, the higher the industrial value added, the greater the number of industrial enterprises, the greater the discharge of industrial sewage. The urban sewage treatment rate can be considered as the treatment capacity of urban sewage, which reflects the quantity and advancement of the construction of sewage treatment plants and sewage treatment equipment in the city. Due to the lack of specific data, we use this indicator instead. The length of urban water supply pipelines and the length of urban drainage pipelines reflect the scale of the city on the one hand and the ability of the city to treat sewage on the other hand.

Table 1 shows the descriptive statistics of observational variables and predictive variables including the number observations (Obs), mean (Mean), standard deviation (Std. Dev.), minimum (Min), and maximum (Max). The total sample contains 18 years of data. The minimum and the maximum industrial sewage discharge values of eastern China are 717.9 and 296318, respectively. Meanwhile, the minimum and the maximum urban sewage discharge values of eastern China are 17827 and 712678, respectively. This fully demonstrates that the differences in sewage discharges in different regions are enormous. Thus it is not appropriate to simply consider comparative analysis when examining the policy effects. Statistics of *ST* also show that there are huge differences in sewage treatment capacity among different regions. The highest sewage treatment rate is

Table 3: Fitting and comparison of predictive variables.

Variable	Treated	Synthetic	Control group
ln *IV*	8.99	8.99	8.37
ln *EN*	9.12	10.54	9.29
ST	0.67	0.67	0.73
ln *SL*	10.35	10.34	9.81
ln *DL*	9.76	9.78	9.42

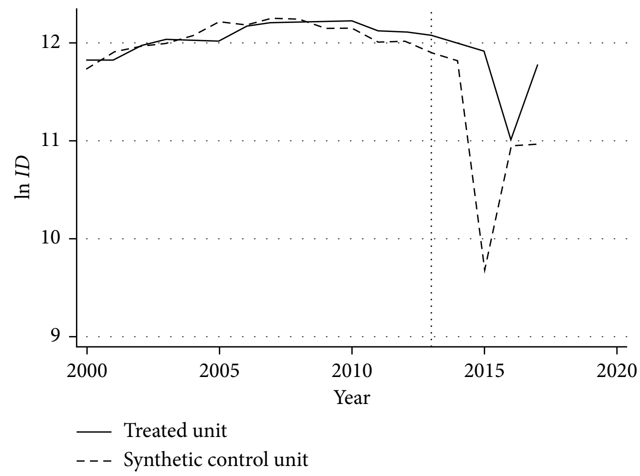

Figure 2: Comparison of industrial sewage discharges between "real Zhejiang" and "synthetic Zhejiang".

Table 4: The weight of the control group.

Province	Unit weight	Province	Unit weight
Beijing	0	Jungian	0
Tianjing	0.02	Fujian	0
Hebei	0	Shandong	0.229
Liaoning	0.64	Guangdong	0.111
Shanghai	0	Guangxi	0
Hainan	0		

Table 5: Fitting and comparison of predictive variables.

Variable	Treated	Synthetic	Control group
ln *IV*	8.99	8.89	8.37
ln *EN*	9.12	9.12	9.29
ST	0.67	0.70	0.73
ln *SL*	10.35	10.35	9.81
ln *DL*	9.76	9.76	9.42

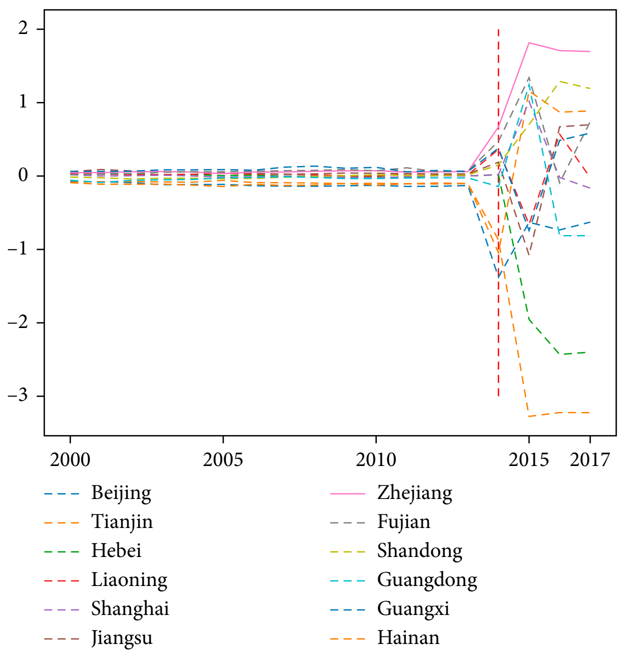

Figure 3: Placebo test.

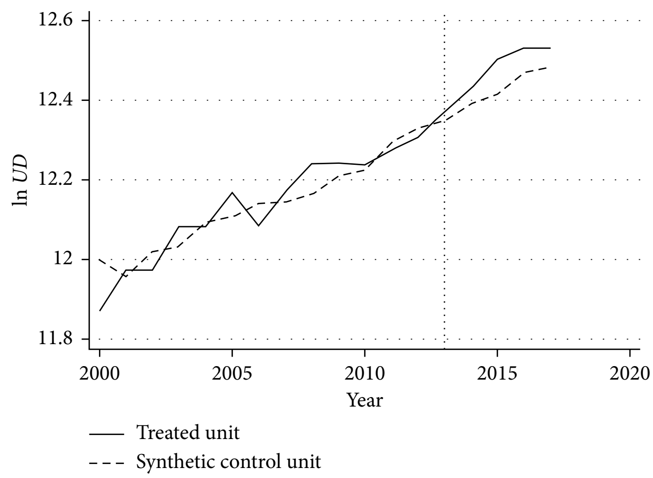

Figure 4: Comparison of urban sewage discharges between "real Zhejiang" and "synthetic Zhejiang".

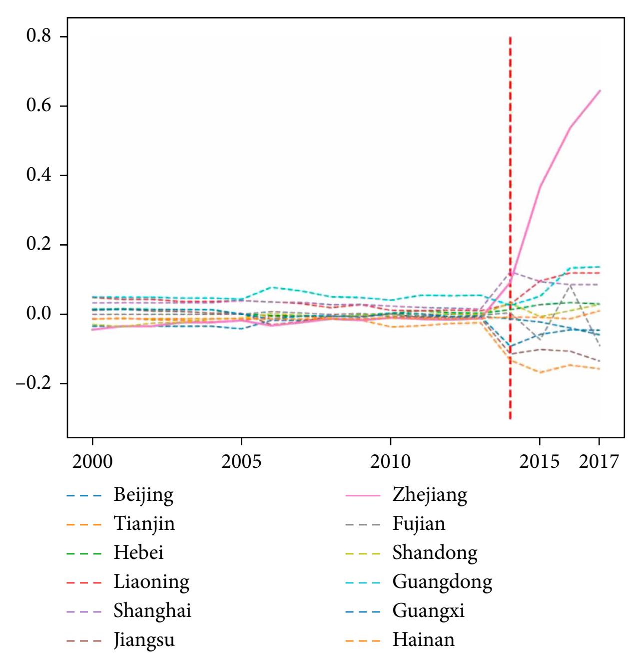

Figure 5: Placebo test.

97.8%. However, the lengths of the water supply and drainage pipes are similar, and there is no difference in magnitude.

5. Empirical Analysis

5.1. Industrial Sewage Discharge. There are two observational variables that we mainly investigate, namely industrial sewage discharge (*ID*) and urban sewage discharge (*UD*). First, in terms of industrial sewage discharge, in order to prevent the occurrence of heteroscedasticity and the mismatch of the fitting results, we logarithmize the original data except *ST*. Through the calculation of the synthetic control method, Table 2 shows the weight combinations that constitute the "synthetic Zhejiang". In the 11 provinces and municipalities, a total of 5 provinces were selected, namely Hebei, Liaoning, Fujian, Guangdong, and Guangxi. Among them, Guangdon's industrial sewage discharge can largely explain Zhejiang's industrial sewage discharge, with a weight of 0.566. Followed by Guangxi, with a weight of 0.255. Fujian has a small explanatory power and its weight is only 0.003.

Table 3 shows the comparison of some important variables between "real Zhejiang" and "synthetic Zhejiang" before the implementation of the "Five Water Co-Treatment" policy in 2014, in which the real and synthesized values of ln *IV* and *ST* were perfectly equal. The synthesized value of ln *SL* differs only from the real value by 0.01, and the synthesized value of

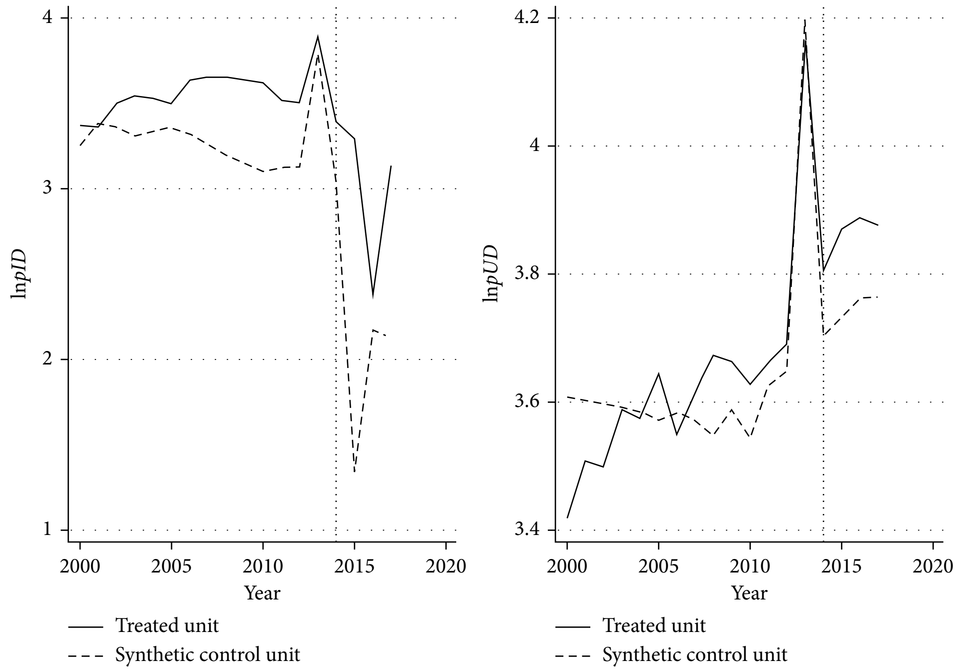

Figure 6: Robustness test.

ln *DL* differs only by 0.02 from the true real. The fitting effect of ln *EN* was poor, but the difference was only 15.6 percent. Overall, the synthesized results of the variables are close to the real situation. Therefore, the synthetic control method fits the characteristics of Zhejiang before the "Five Water Co-Treatment", which is suitable for estimating the effect of the policy.

Figure 2 depicts the trends of industrial sewage discharge in "real Zhejiang" and "synthetic Zhejiang". As can be seen from Figure 2, before the implementation of the "Five Water Co-Treatment" policy, the change paths of the two almost exactly coincide, and "synthetic Zhejiang" has very well replicated the changing path of industrial sewage discharge in Zhejiang. However, after the implementation of the policy, there are obvious differences in the path of change between the two. The industrial sewage discharge of "synthetic Zhejiang" showed a downward trend, but the decline rate was higher than "real Zhejiang". This result just shows that the "Five Water Co-Treatment" policy has not only failed to effectively alleviate the industrial sewage discharge in Zhejiang, but also increased the industrial sewage discharge.

To confirm the reliability of the above empirical results, the "Placebo test" proposed by Alberto et al. (2010) was used to perform the robustness check. The basic idea of the "Placebo test" is: apply the synthetic control method to other provinces and municipalities that have not implemented the "Five Water Co-Treatment" policy, respectively. If these provinces and municipalities also show similar effects to Zhejiang after 2014, it indicates that the "Five Water Co-Treatment" policy has no significant impact on sewage discharge in central Zhejiang. On the contrary, if the effect of Zhejiang after 2014 is significantly different from that of other provinces and municipalities, it indicates that the "Five Water Co-Treatment" policy has a significant impact on Zhejiang's industrial sewage discharge.

Table 6: Inspection of the Kuznets curve of water pollution.

	ln *ID*		ln *UD*	
	(1)	(2)	(3)	(4)
ln *IV*	0.202^{***}	0.910^{**}	0.412^{***}	0.765^{***}
	(2.74)	(2.11)	(11.83)	(3.76)
$(\ln IV)^2$		-0.046^{*}		-0.023^{*}
		(−1.66)		(−1.76)
ln *POP*	0.949^{***}	0.986^{***}	0.291^{**}	0.310^{***}
	(8.19)	(8.39)	(5.34)	(5.61)
CD	-0.000^{**}	−0.000	−0.000	−0.000
	(2.69)	(−1.42)	(−1.46)	(−0.85)
Cons	1.829^{***}	−1.178	6.166^{***}	4.666^{***}
	(2.69)	(−0.61)	(19.23)	(5.13)
Obs	198	198	198	198
R^2	0.6006	0.6062	0.7728	0.7764

Notes: ***, **, and * denote the statistical significance at the 1%, 5%, and 10% level, respectively. t-statistics are reported in parentheses underneath individual coefficients.

According to the results in Figure 3, after the initial implementation of the "Five Water Co-Treatment" policy, the effect of industrial sewage discharge in Zhejiang is positive. Although the positive effect tends to be stable after 2016, it is still significantly higher than that of other provinces and municipalities. However, after the implementation of the policy, the effect of industrial sewage discharge in other provinces and municipalities is obviously different. Therefore, we can be sure that the "Five Water Co-Treatment" policy had a significant impact on industrial sewage discharge in Zhejiang, which is mainly the expansion effect. This result runs counter to the original intention of the government to implement the policy. However, through the analysis of specific projects we found that this is

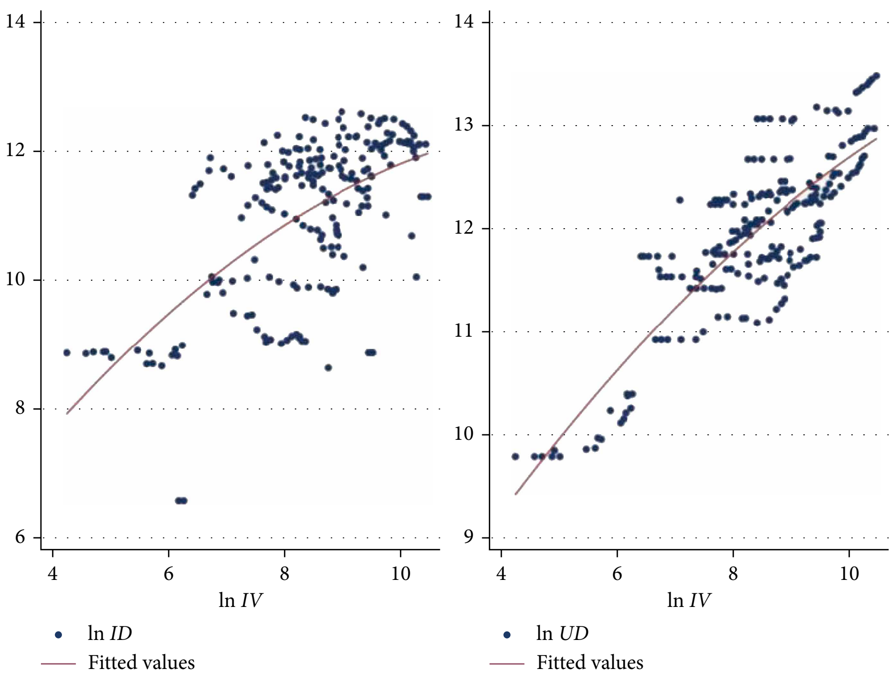

Figure 7: Inspection of the Kuznets curve of water pollution.

not difficult to understand. The main contents of the "Five Water Co-Treatment" project are the renovation of the drainage pipe network, the construction and transformation of the sludge disposal facilities, the construction of sewage treatment facilities, and the construction of flood control facilities. In addition, the policy emphasizes on treating sewage at the right time rather than preventing accidents beforehand, the over construction of these facilities will itself discharge a large amount of sewage. Empirical studies have shown that both large dams and sewage treatment plants have strong economic benefits, therefore, it is not surprising that this is the case [22, 23].

5.2. Urban Sewage Discharge. In terms of urban sewage discharge, through the calculation of the synthetic control method, Table 4 shows the weight combinations that constitute the "synthetic Zhejiang." In the 11 provinces and municipalities, a total of 4 provinces and municipalities were selected, which are Tianjing, Liaoning, Shandong, and Guangdong. Among them, Liaoning's urban sewage discharge can largely explain Zhejiang's urban sewage discharge, with a weight of 0.64. Followed by Shandong, with a weight of 0.229. Guangdong's fitted weight is 0.111, meanwhile Tianjing has a small explanatory power and its weight is only 0.02.

Table 5 reports the comparison of some important variables between "real Zhejiang" and "synthetic Zhejiang" before the implementation of the "Five Water Co-Treatment" policy in 2014, in which the real and synthesized values of ln *EN*, ln *SL*, and ln *DL* were perfectly equal. The synthesized value of ln *IV* differs only from the real value by 0.1, and the synthesized value of *ST* differs only by 0.03 from the true real. They accounted for just 1.1 percent and 0.4 percent of the real values, respectively. Overall, like the situation of industrial sewage discharge, the synthesized results of the variables are close to the real situation in urban sewage discharge. Therefore, the synthetic control method also fits the characteristics of Zhejiang before the "Five Water Co-Treatment" in urban sewage discharge. And it is suitable for estimating the effect of the policy.

Figure 4 reports the trends of urban sewage discharge in "real Zhejiang" and "synthetic Zhejiang". From Figure 4, similar to the trends of industrial sewage discharge in Figure 2, before the implementation of the "Five Water Co-Treatment" policy, the change paths of the two almost exactly coincide, and "synthetic Zhejiang" has replicated the changing path of urban sewage discharge in Zhejiang. However, after the implementation of the policy, there are obvious differences in the path of change between the two. The urban sewage discharge of "synthetic Zhejiang" showed an upward trend, but the increase rate was lower than the "real Zhejiang," implying that the "Five Water Co-Treatment" policy also has a positive effect on urban sewage discharge. And this also goes against the original intention of the government to implement the policy.

As shown in Figure 5, after the implementation of the "Five Water Co-Treatment" policy, consistent with the effect of industrial sewage discharge in Zhejiang, the effect of urban sewage discharge is also positive. And this growth effect has gradually expanded after 2014. However, the effect of urban sewage discharge in other provinces and municipalities is obviously different with Zhejiang and the degree of volatility is much smaller than that of Zhejiang. Therefore, we are also firmly convinced that the "Five Water Co-Treatment" policy has had a significant impact on urban sewage discharge in Zhejiang, which is mainly the expansion effect. This result still runs counter to the original intention of the government to implement the policy. Through the analysis of specific projects, we can also find the reason. Another focus of the work on the "Five Water Co-Treatment" is to dredge the river to prevent urban flooding.

Table 7: Inspection of water pipeline dimensions.

	ln *ID*		ln *UD*	
	(1)	(2)	(3)	(4)
ln *SL*	−0.048	−0.112	0.131**	0.139**
	(−0.19)	(−0.37)	(2.46)	(2.26)
ln *DL*	0.344**	0.426***	0.005	−0.009
	(2.35)	(2.70)	(0.17)	(−0.29)
ln *POP*		0.027		0.156
		(0.05)		(1.57)
ln *pGDP*		−0.029		0.098
		(−0.07)		(1.12)
ST		0.365		−0.249***
		(0.78)		(−2.67)
AI		−0.005		−0.001
		(−0.74)		(−0.93)
Cons	8.510***	8.340**	10.523***	9.368***
	(3.58)	(2.04)	(20.79)	(11.27)
Time fixed effects	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes
Obs	207	207	207	207
R^2	0.4936	0.5109	0.7382	0.7616

Notes: ***, **, and * denote the statistical significance at the 1%, 5%, and 10% level, respectively. t-statistics are reported in parentheses underneath individual coefficients.

5.3. Robustness Check. Natural experiments on industrial sewage discharge and urban sewage discharge suggest that the "Five Water Co-Treatment" policy has expanded sewage discharge. In order to test the robustness of the above conclusions, and also to explore whether there is a difference between the total amount and the per capita, we replace the original dependent variable with per capita industrial sewage discharge and per capita urban sewage discharge, and incorporate it into the synthetic control model.

The results of the robustness test for the synthetic control experiment of per capita industrial sewage discharge and urban sewage discharge are shown in Figure 6. The results of the robustness test are consistent with the basic model. On the one hand, the per capita industrial sewage discharge of "synthetic Zhejiang" showed a downward trend, but the decline rate was higher than "real Zhejiang". On the other hand, the per capita urban sewage discharge of "synthetic Zhejiang" showed an upward trend, but the increase rate was lower than the "real Zhejiang". These results, from a per capita perspective, also suggest the positive effects of the "Five Water Co-Treatment" policy on sewage discharge.

5.4. Discussion. Summarizing the results of the policy effect of industrial sewage discharge and urban sewage discharge, we believe that multiple environmental policies may not achieve the desired results. To sum up the cause, we believe that there may be four reasons for this "abnormal" phenomenon. First, massive infrastructure construction, such as the repair and construction of dams and sewage treatment plants, may itself exacerbate the discharge of industrial sewage. And when the workers in the project work in the city, the pressure of urban sewage discharge will also increase, and eventually the result of sewage discharge is contrary to the expected goal. Secondly, the expansion of population size and economic scale may be the cause of the "failure" of the "Five Water Co-Treatment" policy. With the growing population and the increasing frequency of economic activities, the sewage generated during production and consumption will inevitably expand. Thirdly, with the economic development and the improvement of per capita income, the consumption of per capita energy and water resources continues to rise, which in turn makes the "Five Water Co-Treatment" policy seem to increase the per capita sewage discharge. Finally, it is also possible that due to co-governance, sewage discharge pipes have been added, which may increase the normal discharge of sewage and reduce irregular emissions, thus leading to the "effectiveness" of the "Five Water Co-Treatment" policy.

6. Extended Analysis

6.1. Inspection of the Environmental Kuznets Curve. One of the objectives of the implementation of the "Five Water Co-Treatment" policy is to promote economic development and economic restructuring in Zhejiang. Among a wide range of the literature that has investigated the relationship between economic development and pollution emissions, one of the most discussed issues is the environmental Kuznets curve (EKC). The environmental Kuznets curve is a hypothesis to describe the relationship between socio-economic development and the ecological environment using an inverted U-shaped curve, which is characterized by an income turning point: the level of per capita income (or GDP) where emissions start to decline rather than increase [24, 25].

Some literatures have investigated the practical situation of EKC hypothesis in China, which proved that environmental EKC hypotheses have regional differential characteristics and will change with conditions [26–28]. In Section 5, we conducted a preliminary analysis of the reasons for the increase in sewage discharge caused by the "Five Water Co-Treatment" policy, and then we will further examine its determining factors. Since dams, sewage treatment plants and facilities can be regarded as part of industrial value added, which also represents the industrial development level of the region, in order to examine the impact of industrial added value on sewage discharge, and further explore the potential EKC phenomena, our design equation is as follows:

$$\ln ID_{it} = \alpha_0 + \alpha_1 \ln IV_{it} + \alpha_2 (\ln IV_{it})^2 + \alpha_3 Z_{it} + \varepsilon_{it}, \quad (9)$$

$$\ln UD_{it} = \alpha_0 + \alpha_1 \ln IV_{it} + \alpha_2 (\ln IV_{it})^2 + \alpha_3 Z_{it} + \varepsilon_{it}, \quad (10)$$

where ln *ID*: denotes the industrial sewage discharge; ln *UD*: denotes the urban sewage discharge; ln *IV*: denotes the industrial added value; *Z*: denotes other control variables, including population (ln *POP*) and urban population density (*CD*). In order to prevent the occurrence of heteroscedasticity and the deviation of regression results, we conducted logarithmic treatment on industrial sewage discharge, urban sewage discharge, industrial added value and population.

Our estimation results are presented in Table 6. Columns 1 and 2 use ln *ID* as the interpreted variable. Columns 3 and 4 use ln *UD* as the interpreted variable. Columns 2 and 4 in Table 6 add the squared term of ln *IV* to explore potential EKC. In columns 1 and 3, the coefficients of ln *IV* estimate positive and highly significant (parameter estimates of 0.202, $p < 0.01$; 0.412, $p < 0.01$), suggesting that the increase of industrial added value has aggravated the discharge of industrial sewage and urban sewage. Adding the squared term of ln *IV* does not substantially change this result, the coefficients of ln *IV* remain positive and highly significant in column 3 and 4 (parameter estimates of 0.910, $p < 0.05$; 0.765, $p < 0.01$). And the coefficient of the squared term itself is significantly negative in columns 3 and 4 (parameter estimates of −0.046, $p < 0.1$; −0.023, $p < 0.1$), suggesting that there is indeed an environmental EKC relationship between industrial value added and sewage discharge in the eastern part of China. Among the control variables, the coefficients of ln *POP* are positive, and pass the 1% level of significance test, which indicates that with the expansion of population, sewage discharge will naturally increase. In contrast, the coefficients of *CD* are all 0.000 and only pass the 5% level of significance test in the first column, which means that urban population density has no significant impact on sewage discharge. The above results confirm our 5.4-Section speculation about the "failure" of the "Five Water Co-Treatment": the real reason for the expansion of industrial sewage and urban sewage discharge lies in the output growth of the industrial sector and population expansion. And the "Five Water Co-Treatment policy may accelerate the expansion of some industrial sectors.

However, although the inverted U-shaped relationship does exist, has eastern China crossed the inflection point and entered the second half of the inverted U-shaped curve? To explain this problem more intuitively, we plot the quadratic fit of ln *IV* with ln *ID* and ln *UD*, and obtain Figure 7. As shown in Figure 7, the relationship between ln *IV* and sewage discharge indicators is almost linear, with no apparent marginal decline. This suggests that almost all observations are still in the left half of the inverted U-shaped relationship. Although the eastern part of China is relatively developed, it has not yet entered the second half of the EKC. Of course, this result also indirectly supports the explanation of the phenomenon that the "Five Water Co-Treatment" policy leads to more sewage discharge.

6.2. Inspection of Water Pipeline Dimensions. Last but not least, in order to verify the last conjecture of Section 5.4, the increase in sewage discharge is actually due to the increase in pipes, which makes the discharge of sewage more standardized. Eventually, the sewage discharge appears to increase statistically, which is essentially an increase in sewage treatment capacity. Therefore, the following equation is constructed:

$$\ln ID_{it} = \alpha_0 + \alpha_1 \ln SL_{it} + \alpha_2 \ln DL_{it} + \alpha_3 Z_{it} + \beta_i + \beta_t + \varepsilon_{it}, \quad (11)$$

$$\ln UD_{it} = \alpha_0 + \alpha_1 \ln SL_{it} + \alpha_2 \ln DL_{it} + \alpha_3 Z_{it} + \beta_i + \beta_t + \varepsilon_{it}, \quad (12)$$

where ln *ID* denotes the industrial sewage discharge; ln *UD* denotes the urban sewage discharge; ln *SL* denotes the length of the water supply pipes; ln *DL* denotes the length of the drainage pipes; *Z* denotes other control variables, including population (ln *POP*), per capita GDP (ln *pGDP*), the sewage treatment rate (*ST*), and industrial structure (*AI*). Again, to prevent the occurrence of heteroscedasticity and the deviation of regression results, we conducted logarithmic treatment on industrial sewage discharge, urban sewage discharge, the length of the water supply pipes, the length of the drainage pipes, population, and per capita GDP. Referring to the existing literature on the definition of industrial structure upgrading, we design the equation as follows:

$$AI = \frac{S}{I}, \quad (13)$$

where *S* is the output of the server sector, and *I* is the output of the industrial sector. The ratio of the two represents the degree of servitization of economic structure, that is, the degree of advanced industrial structure.

We apply a two-way fixed effects panel model, fixing the fixed effects of the individual and the year, to estimate equations (11), (12), and obtain the results reported in Table 7. As shown in columns 1 and 2 of Table 7, the expansion of drainage pipes increases the discharge of industrial sewage (parameter estimates of 0.344, $p < 0.05$; 0.426 $p < 0.01$). The coefficients of other control variables are all not significant, implying that for industrial sewage discharge, the only real factor is the increase in drainage pipes. Theoretically, the other conditions remaining unchanged, the effect of the increase of drainage pipe length on industrial sewage discharge should be neutral, that is, the length of drainage pipe does not change the industrial sewage discharge in essence. A reasonable explanation for this phenomenon is that the increase of discharge pipes absorbs industrial sewage that has not been discharged through the pipeline, and is a process of rationalizing and standardizing industrial sewage discharge. At the same time, this also imply an increase in sewage treatment capacity. According to the above results of columns 3 and 4, the expansion of supply pipelines seems to encourage the urban sewage discharge (parameter estimates of 0.131, $p < 0.05$; and 0.139, $p < 0.05$, respectively). On the one hand, the increase in the length of the water supply pipeline reflects the expansion of the city scale and the convenience of access to water resources. On the other hand, it also increases the possibility of residents wasting water resources. Meanwhile, the estimate of *ST* indicates that sewage treatment rate can effectively inhibit the discharge of urban sewage (parameter estimates of −0.249, $p < 0.01$). However, other control variables have no significant impact on urban sewage discharge. Based on the above results, it can be seen that, the effect of the "Five Water Co-Treatment" policy is not as simple as it appears to be ineffective. In fact, the increase of water pipelines is the main factor for the expansion of sewage discharge. The "Five Water Co-Treatment" policy promotes the construction of pipelines, which reflects the improvement of sewage treatment capacity.

7. Conclusions

The designing of an effective environmental governance policy is an important issue of concern to the academic and policy communities. This paper attempts to investigate whether the environmental policy mix can really work. Taking the "Five Water Co-Treatment" policy of Zhejiang Province as an example, we applied the synthetic control method to examine the impact of multi-objective environmental policies on industrial sewage discharge and urban sewage discharge in Zhejiang. Further, the study provides some evidence of the reasons for the effects of the "Five Water Co-Treatment" policy. First, we analyzed the impact of industrial value added on sewage discharge and explored potential EKC relationships. Secondly, we also explain the problem in terms of the effect of the length of the water pipeline.

Taking into account the level of economic development and geographical characteristics, we selected a group of 11 provinces and municipalities in eastern China as the control group to create a counterfactual of Zhejiang's sewage discharge changes and compare them with the real values. In terms of industrial sewage discharge, a total of five provinces and municipalities participated in the fitting, namely Hebei, Liaoning, Fujian, Guangdong, and Guangxi. And in urban sewage discharge, a total of 4 provinces and municipalities were selected, namely Tianjing, Liaoning, Shandong, and Guangdong. The results of comparison between the synthetic value and the real value before the implementation of the policy shows that the synthetic control method well explain the variation of industrial sewage discharge in Zhejiang province. The industrial sewage discharge of "synthetic Zhejiang" showed a downward trend, but the decline rate was higher than "real Zhejiang," and the urban sewage discharge of "synthetic Zhejiang" showed an upward trend, but the increase rate was lower than the "real Zhejiang." These result imply that the "Five Water Co-Treatment" policy has not only failed to effectively alleviate the industrial sewage discharge in Zhejiang, but also increased the sewage discharge.

However, in-depth exploration of the causes of this phenomenon, we believe that the effect of the "Five Water Co-Treatment" policy is not as simple as it appears to be ineffective. First, the "Five Water Co-Treatment" policy is more a policy mix for service economic development. The main contents of the "Five Water Co-Treatment" project are the renovation of the drainage pipe network, the construction and transformation of the sludge disposal facilities, the construction of sewage treatment facilities, and the construction of flood control facilities. Secondly, the reason for the expansion of industrial sewage and urban sewage discharge also lies in the output growth of the industrial sector and population expansion. And the "Five Water Co-Treatment policy accelerates the expansion of some industrial sectors. Finally, the increase of water pipelines is the key factor for the expansion of sewage discharge. The "Five Water Co-Treatment" policy promotes the construction of pipelines, which reflects the improvement of sewage treatment capacity.

Implications of this study are significant. We suggest that the policy of "Five Water Co-Treatment" should continue to advance, even though at the current stage it seems to increase the discharge of sewage. However, we believe that this is a process of standardizing sewage discharge and an embodiment of enhanced sewage treatment capacity. The actual policy effects may not be fully reflected at present.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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