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Original Research

The Pollution Reduction Effect of Target Responsibility System of Environmental Protection: Evidence from China

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Abstract

Based on the panel data of 30 provinces from 2007 to 2020, this study identifies the effect and mechanism of China's Target Responsibility System of Environmental Protection (TRSEP) on pollution reduction, then analyzes its impact on green economic growth. The conclusion indicates that TRSEP can spur pollution reduction for obligatory pollutants such as SO_2 and COD, which is still valid after a series of robustness tests. Specifically, China's TRSEP can promote pollution reduction by increasing environmental protection expenditure, levying pollution fees, and strengthening environmental administrative penalties. Furthermore, heterogeneity analysis shows that the pollution reduction effect of TRSEP is more significant in regions that implemented carbon emissions trading scheme pilots. Meanwhile, the reduction effect of the TRSEP is insignificant for non-obligatory pollutants such as industrial waste gas and industrial sewage. Moreover, implementing the TRSEP is conducive to promoting green economic development. Accordingly, this study suggests that governments should gradually increase the types of pollutant constraints, promote the synergy and complementarity between different environmental policies, and combine economic incentives with administrative regulation in the process of pollution control.

Keywords: target responsibility system of environmental protection, pollution reduction, green economic growth, local government, environmental governance

Introduction

Targets play important roles in performance improvement [1]. Therefore, target setting widely occurs in economic and social development: task performance goals of individuals, profit targets in private organizations, and nonprofit targets of public organizations [2]. It is one of the most important forms of setting targets in organizational management. As a policy instrument, target-setting has recently attracted significant interest from various countries that have implemented government performance management

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by setting and promoting goals [3-6]. For instance, the Chinese government has gradually established a target responsibility system since the mid-1980s. Specifically, the government and relevant departments set quantifiable indicators based on policy targets, which are clarified between the superior government and subordinate government by signing a target responsibility agreement. Then, rewards and punishments should be imposed on the subordinate government according to assessment results. Therefore, targets and pressure are transmitted among different levels of government, and ultimately, the target responsibility system is established.

Since 2006, the target responsibility system has been introduced into China's environmental governance due to the pressure of energy conservation and pollution control, and the Target Responsibility System of Environmental Protection (TRSEP) was formed [7]. Specifically, the mandatory targets of reducing major pollutants (sulfur dioxide and chemical oxygen demand) were introduced to China's target responsibility system in the 11th Five-Year Plan for National Economic and Society Development. The State Council issued the National Control Plan for the Total Emissions of Major Pollutants, which proposed that the emissions of SO_2 and COD must decrease by 10% in 2010. The national emissions of SO_2 and COD should be controlled within 22.94 million tons and 12.73 million tons, respectively. Considering the significant differences in each province's environmental quality, emission base, and economic development level, national pollution reduction targets are decomposed at the provincial level. At the same time, each province's targets must be included in the 11th Five-Year Plan of provincial governments, and the central government should assess it. Thus, the decomposition, release, and assessment of mandatory pollutant emission reduction targets constitute the primary mode of China's TRSEP.

Also, the performance of provincial pollutant emission control is linked with provincial leaders' career advancement. To effectively count, monitor, and assess the discharge of pollutants, the State Council issued multiple institutional documents such as the Monitoring Measures for Total Emission Reduction of Major Pollutants, the Statistical Measures for Total Emission Reduction of Major Pollutants, and the Method for Assessing the Total Emissions of Major Pollutants. The publication and implementation of these policy documents have clarified the local governments' specific targets and responsibilities. Meanwhile, the Method for Assessing the Total Emissions of Major Pollutants established a "one-vote veto" rule for local officials if they fail to achieve the mandatory pollutant emission reduction targets [2]. Subsequently, the provincial pollutant emission control target is decomposed into prefecture- and county-level cities. Through the hierarchical decomposition and assessment of environmental protection targets, the TRSEP can be implemented from top to bottom. Since then, the State Council has issued the Comprehensive Work Plan for Energy Conservation and Emission Reduction during the 12th Five-Year and 13th Five-Year periods, indicating that TRSEP has been continued and further strengthened until now.

An increasing body of literature has focused on the pollution reduction effect of China's TRSEP since 2006. Some literature focused on the firm level, proving that China's TRSEP can not only improve green technological innovation [8] but also reduce firms' pollutant emissions [9]. Another part of the literature analyzes the effect of China's TRSEP on pollutant emissions from a government perspective [10]. Although the pollution reduction effect of China's TRSEP has been demonstrated, the mechanism has not been accurately revealed. Additionally, Porter and van der Linde [11] insisted that appropriate environmental regulation could help to achieve a win-win situation between the environment and the economy. And there is still no evidence that the TRSEP can realize the dual goals of pollution reduction and green economic growth. We contribute to this literature by using empirical models to measure the impact and mechanism of China's TRSEP on pollution reduction and further analyze the effect of TRSEP on green economic growth.

The rest of this paper is organized as follows. The next two sections review the current studies and propose the theoretical analysis. "Materials and Methods" section illustrates the data, variables, and empirical models. "Results and Discussion" section presents the empirical findings and results. "Conclusions" section provides conclusions, policy implications, and research limitations.

Literature Review

Although some counties and regions have attempted environmental governance measures by setting environmental protection targets, such as EU national greenhouse gas reduction targets, the GHG emission reduction goal in the American Clean Energy and Security Act of 2009, and the 17 Sustainable Development Goals of the 2030 Agenda, which was signed in 2015 by 193 member states of the United Nations [12], there has not been a formal arrangement of TRSEP like China, so the existing research of TRSEP mainly focused on China's practices, which can be divided into two groups.

The first group is theoretical research that explored various aspects of the system design, operating mechanism, and the characteristics of TRSEP. From the perspective of system design, the studies argue that the core of China's TRSEP is how to set environmental protection targets for local governments [7]. Kostka [10] suggests that obligatory environmental targets are suitable for managing issues with easily identifiable pollution sources and are easy to verify. The operation of TRSEP also includes target setting, allocating, and assessment. Specifically, the central government stipulates major pollutant reduction targets and then decomposes targets and tasks from top to bottom. Moreover, the superior government assesses the local government to achieve environmental targets. The assessment results are linked to the rewards, punishments, appointments, and official promotions. Generally, the chief leaders will lose the chance to be promoted if the local governments fail to meet the major pollutant emission reduction targets [13]. Hence, TRSEP has typical characteristics of top-down environmental goal setting and mandatory constraints. The local governments are expected to spare no effort to strengthen environmental governance to meet mandatory environmental protection targets under the "one-vote veto" rule. However, the efforts and environmental governance encouraged by the TRSEP have not yet been theoretically summarized.

The second group is empirical research that evaluates the environmental and economic effects of TRSEP. Regarding economic effects, Zhang [2] argued that environmental targets constrained GDP growth goals. From the perspective of local governments, the intense pressure of environmental goals encourages local governments to adopt more strict environmental regulations and reduce economic contributions created by pollution-intensive industries to realize sustainable development. Additionally, strict environmental regulations and even electricity conservation measures may be used to reduce the production scale of energy-intensive and pollution-intensive enterprises. Moreover, implementing TRSEP enhances corporate innovation incentives, especially green technological innovation [14]. Wang et al. [9] believed that TRSEP increased the burdens of firms in the short term, but technological innovation offset the compliance costs of environmental regulation, thus improving firms' TFP in the long term. However, the TRSEP may significantly dampen the high-quality development of energy-intensive firms [13]. Yan et al. [15] find that a moderate environmental target responsibility system can improve environmental quality, promote innovation, and enhance social welfare. Overall, the TRSEP sets green and sustainable development requirements for local areas from the top-level design, which introduces environmental protection as an essential constraint in economic growth. Specifically, under the background of promoting the comprehensive green transformation of the economy and society in China, it has not been effectively revealed whether this institutional practice can achieve green economic growth while realizing pollution reduction.

Furthermore, some scholars have analyzed the environmental effects of TRSEP, which is closely related to this study. From the perspective of new performance management, Liang and Langbein [16] used the provincial panel data. They found that TRSEP reduced air pollutant emissions, which are the most publicly visible among the targeted pollutants. Wu et al. [17] empirically confirmed that the assessment for environmental targets is only significantly correlated with obligatory high-visibility environmental pollutant emissions, such as sulfur dioxide. Meanwhile, this finding is highly similar to Chen and He [18]. Kostka [10] argued that introducing mandatory targets included in TRSEP generated unanticipated outcomes of environmental protection, which could reduce the total amounts of mandatory pollutant emissions. Wang et al. [9] considered TRSEP as a typical mandatory environmental policy and proved that TRSEP can not only significantly improve corporate TFP but also decrease pollutant emissions. Because the primary responsibility of TRSEP is the local government, its mechanism for achieving pollution reduction through influencing government environmental governance behavior has not been empirically analyzed.

In summary, the existing studies have theoretically analyzed the design and characteristics of TRSEP and then empirically tested the pollution reduction effect of TRSEP. However, the mechanism for reducing pollution by influencing government environmental governance behavior has not been theoretically illustrated and empirically tested. In addition, it has not been effectively revealed whether implementing the TRSEP can achieve regional green economic growth. Meanwhile, identifying this mechanism is of great practical significance in optimizing the design of TRSEP, incentivizing local government pollution control behavior, and ultimately achieving an economic green transformation. To fill these gaps, this study utilizes empirical models to analyze the impact and mechanism of China's TRSEP on pollution reduction and further analyze its impact on regional green economic growth, which provides policy implications for optimizing this institutional system and China's pollution governance. For a clearer presentation of the paper's structure, the flowchart diagram is shown in Fig. 1.

Theoretical Hypothesis

In order to vividly observe the variation of pollutant emissions in China, this paper selects sulfur dioxide (SO_2) and chemical oxygen demand (COD) emissions as the main indicators' we plot the change in the total pollutant emissions in China from 2003 to 2020 (see Fig. 2). It can be preliminarily observed that: (1) during the period from 2003 to 2006, the emissions of SO_2 and COD have shown slow upward trends; (2) after 2006 and before 2011, the emissions of SO_2 and COD gradually decreased, and there was a slight increase in 2011; (3) after 2011, the emissions of SO_2 has shown rapidly downward trends. Meanwhile, the emission of COD also gradually decreased since 2011, and there has been a rebound in 2020. Therefore, these findings preliminarily suggest that TRSEP may have caused the turning point of SO_2 and COD emissions in 2006.

Since China's TRSEP was implemented in 2006, local governments have been incentivized to promote pollution control and achieve these targets [19]. On the one hand, recognition and rewards may be

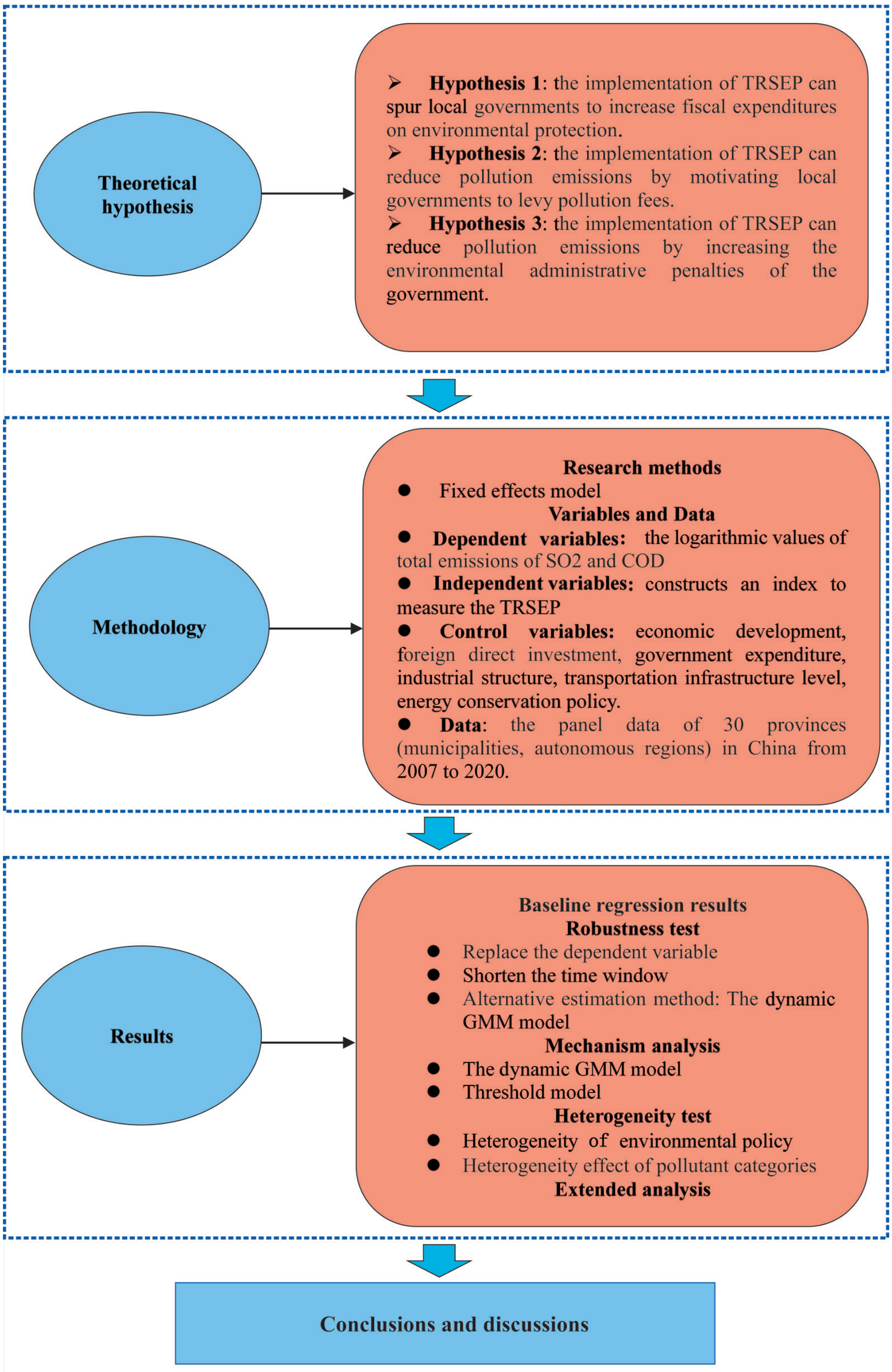

Fig. 1. Methodological flowchart for analysis in this paper.

given to governments that are evaluated as qualified or outstanding and may include support for pollution control and environmental capacity building in the future. On the other hand, local governments that fail to meet pollutant emission reduction targets may lose the environmental protection honorary titles granted by the central government and the qualification to add major pollutant discharge construction projects. At the same time, their chief leaders may lose the chance to be promoted if the targets are evaluated as ineligible. Therefore, TRSEP has changed the career incentive structure of local officials [20]. Achieving the mandatory pollutant emission reduction targets is crucial for local governments and officials. This means that TRSEP can motivate local governments to take a series of measures to achieve expected targets [10]. Previous studies indicate that governments usually adopt three kinds of measures to handle environmental pollution. Specifically, it includes increasing government expenditure on environmental protection, levying environmental fees, and strengthening environmental supervision and penalties.

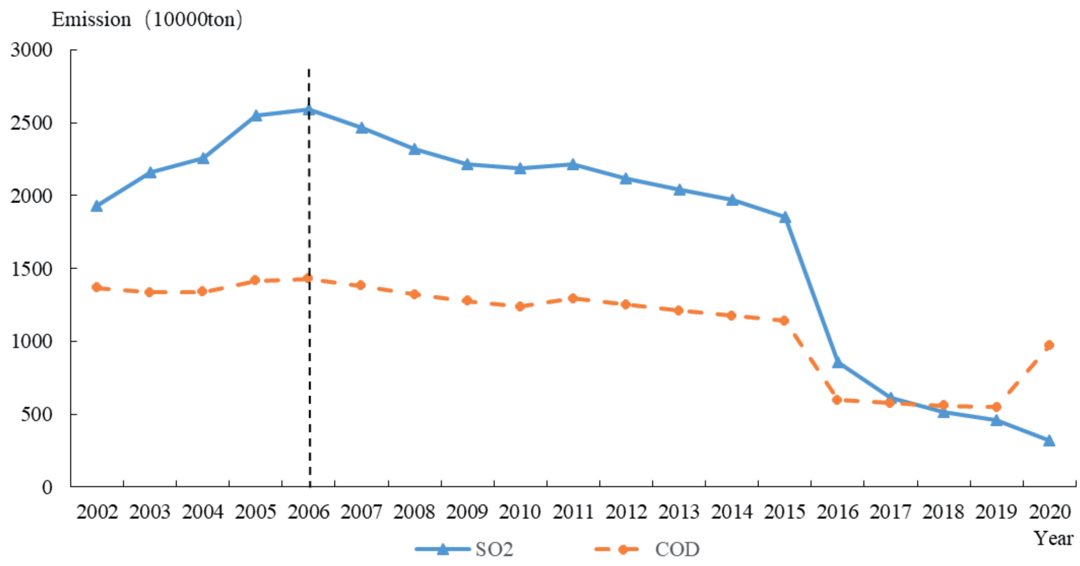

Fig. 2. Change in the total emission of SO_2 and COD in China from 2002 to 2020.
Notes: This relevant data is derived from the EPS database and China Environmental Yearbook. Considering that the government revised the statistical standards of SO_2 and COD in 2011, we adjusted the pollution emission data after 2010 according to the previous standards to maintain consistency in statistical standards. Therefore, the emission only includes the emissions of pollutants from industrial and domestic sources.

Firstly, the government can increase expenditure on environmental protection to promote pollution control. Under the pressure of TRSEP, local governments can promote economic incentives such as increasing government expenditure on environmental protection to provide sufficient financial support for reducing pollution emissions. In general, implementing environmental policies requires sustained and sufficient financial investments. The existing studies show that governments' environmental protection expenditure can provide funds to develop pollution control technologies, build pollution control facilities, and produce cleaner products, thereby promoting pollution reduction [21]. Therefore, fiscal expenditure on environmental protection is an important mean for local governments to govern the environment. Especially under the pressure of environmental protection target assessment constraints, local governments prefer to increase environmental fiscal expenditure to handle environmental pollution. Therefore, this study proposes Hypothesis 1.

Hypothesis 1: Implementing TRSEP can spur local governments to increase fiscal expenditures on environmental protection, thereby forming economic incentives to promote pollution reduction.

Secondly, levying pollution fees is an important tool for governments to achieve environmental protection goals. For example, local governments have the right to formulate standards for collecting pollutant discharge fees, assess the categories and quantities of pollutants, and manage and supervise pollutant discharge fees [22]. The existing research indicates that levying pollution fees can help mitigate the emissions of SO_2 and COD [23]. Specifically, levying pollution fees is an important way to effectively achieve the internalization of external costs. Overall, levying pollution fees can increase production costs, encouraging producers to improve resource utilization efficiency and accelerate technological innovation, thus promoting pollution reduction. Therefore, this study proposes Hypothesis 2.

Hypothesis 2: Implementing TRSEP can reduce pollution emissions by motivating local governments to levy pollution fees.

Thirdly, strengthening environmental administrative penalties. China's environmental management highly relies on government administrative regulations, which mainly include enacting increasingly stringent laws and imposing administrative supervision, thereby reducing environmental violations [24]. Administrative penalties executed by local governments on enterprises that have violated environmental laws are known as environmental administrative penalties [25]. Specifically, it refers to the administrative sanctions imposed by environmental administrative agencies on individuals or organizations who commit environmental violations in accordance with environmental protection laws. Therefore, the stringent environmental protection target will incentivize local governments to strengthen environmental administrative penalties, which deter environmental violations and reduce pollution emissions. Therefore, this study proposes Hypothesis 3.

Hypothesis 3: Implementing TRSEP can reduce pollution emissions by increasing the government's environmental administrative penalties.

Materials and Methods

Research Methods

Based on the institutional background and analysis, the central government has decomposed and assigned control targets for major pollutants at the provincial level since 2006. Then, clarify the targets and tasks of each provincial government by signing a responsibility letter for the major pollutants. Overall, provincial governments must be supervised and responsible for the central government. According to the operational model of this institution between central and provincial governments, and considering the availability of data, this study uses the panel data of 30 provinces in China from 2007 to 2020. It constructs a fixed effects model to investigate the pollution reduction effects of TRSEP. Referring to Xiong et al. [26], the fixed effects model is constructed as follows:

$$Pollutant_{it} = \alpha_0 + \alpha_1 TRSEP_{it} + \lambda X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \tag{1}$$

where $Pollutant_{it}$ denotes the total pollutant emissions of province i in year t, $TRSEP_{it}$ measures the constraint intensity of the Target Responsibility System of Environmental Protection, X_{it} represents a series of control variables, μ_i and γ_t are district and time fixed effects, respectively, and ε_{it} represents the error term.

Variables and Data

Measurement of Independent and Dependent Variables

Dependent variables. The existing literature on the measurement of pollution reduction includes the total amount of pollution emissions, comprehensive pollution emission index, pollution emission performance indicators, etc. Considering that the control targets for major pollutants were taken as the constraint indicators at the beginning of implementing the TRSEP in China, this study mainly uses the logarithmic values of total emissions of SO_2 (Polso) and COD (Polcod) as the dependent variables. Also, per capita emissions and pollutant reduction rates are introduced into the robustness tests as proxy-dependent variables.

Independent variables ($TRSEP_{it}$). The key to the empirical design of this study is to find a reasonable variable to measure the TRSEP. Specifically, it is a challenge to quantify the TRSEP due to the diversified objectives and contents of the major pollutant targets of this system. Also, it can only comprehensively measure the constraint strength of TRSEP if the emission control target of a certain pollutant is used. Therefore, referring to the calculation method of environmental regulation intensity in the research of Huang et al. [27], this study constructs an index to measure the TRSEP based on each province's major pollutant control targets and GDP growth targets. The specific calculation process of this indicator is presented in Appendix A.

Measurement of Control Variables

This study also selects several control variables that may affect pollution reduction: (1) Economic development (Lnpergdp). The Environmental Kuznets Curve (EKC) hypothesis believes that economic development level is closely related to environmental pollution [28, 29]. (2) Foreign direct investment (Fdipro). Foreign direct investment may be beneficial in introducing advanced technologies and industries, which can provide financial and technical support for sustainable green production and pollution reduction. (3) Government expenditure (Financerate). Local governments have the motivation to "compete for growth" and are inclined to use fiscal expenditures for projects with quick economic benefits. Expanding government expenditure can aggravate environmental pollution through the substitution effect and growth effect, which is unfavorable to improving environmental quality. (4) Industrial structure (Ind). Industrial structure upgrading can increase the proportion of technology and knowledge-intensive industries in economic growth, which is conducive to encouraging investments in clean technology research and development and improving energy efficiency and technical level, thus controlling pollution emissions. (5) Transportation infrastructure level (Road). Well-developed transportation infrastructure promotes the agglomeration of economic activities, leading to the expansion of energy consumption and increasing pollution emissions. Meanwhile, it also promotes the effective allocation of resources and improves production efficiency, which may reduce pollution emissions. (6) Energy Conservation Policy (Energy). Considering that the energy-saving policy has been implemented since China's 11th Five-Year Plan, this paper introduces the energy-saving target as a control variable to eliminate the impact of pollution reduction.

Data

This study selects the panel data of 30 provinces (municipalities, autonomous regions) in China from 2007 to 2020 as research samples. The data are mainly collected from the China Statistical Yearbook, China Environmental Yearbook, China Statistical Yearbook on Environment, Express Professional Superior (EPS) Data, the official websites of the provincial governments, the National Bureau of Statistics (http://www.stats.gov.cn/), and other relevant documents. The interpolation method is used to complement the missing data. Meanwhile, all economic variables related to monetary value were deflated based on 2000 to eliminate the impact of price factors and inflation. Table 1 presents the variables' definitions, indicators, and descriptive statistical results.

Table 1. Definitions indicators and descriptive statistics of the variables.

Variables	Definition	Calculation	Samples	Mean	Standard Deviation
Polso	The emissions of SO_2	The logarithm of the emissions of SO_2	420	12.701	1.223
Polcod	The emissions of COD	The logarithm of the emissions of COD	420	12.801	0.954
TRSEP	The constraint intensity of TRSEP	Index to measure TRSEP (this study utilizes a comprehensive index to measure the constraint intensity of TRSEP; the calculation process is shown in Appendix A)	420	1.671	1.590
Lnpergdp	Economic development	The logarithm of real GDP	420	10.294	0.633
Fdipro	Foreign direct investment	The ratio of foreign direct investment to GDP	420	0.511	1.720
Financerate	Government expenditure	The ratio of local fiscal expenditure to GDP	420	24.843	11.051
Ind	Industrial Structure	The ratio of the value of the tertiary industry to the GDP	420	45.024	9.897
Road	Transportation infrastructure level	Highway mileage per capita	420	36.842	22.902
Energy	Energy conservation policy	The reduction rate of energy consumption per unit of GDP	420	3.235	1.181

Results and Discussion

Baseline Regression Results

The estimation results of Equation (1) are presented in Table 2. Columns (1) and (3) show the regression results without control variables, and Columns (2) and (4) describe the regression results of the same Equation with control variables. As shown in Table 2, TRSEP is significantly negative regardless of whether the dependent variable is Polso or Polcod. Specifically, when the fixed effects and control variables are controlled, the TRSEP has a significant negative impact on Polso and Polcod, indicating that implementing China's TRSEP promotes the pollution reduction of SO_2 and COD. It will generate more substantial pollution reduction effects when the constraint intensity of TRSEP is increased.

Robustness Test

Replace the Dependent Variable

The dependent variable used in the benchmark regression is the major pollutant emissions. According to the research of Zhang et al. [30], the replacement of dependent variables was used to avoid the impacts of economic scale and pollution emission among provinces on the regression results. Specifically, per capita emissions of SO_2 (Perpolso) and per capita emissions of COD (Perpolcod) are regarded as the dependent variables, and the estimation results are presented in Table 3. The results show that TRSEP negatively correlated with Perpolso and Perpolcod with coefficients of -4.325 and -10.891, respectively. Consequently, the conclusion indicates that China's TRSEP can promote pollution reduction and is robust after replacing the dependent variables.

Shorten the Time Window

In addition to the TRSEP, China has gradually strengthened environmental regulations and recently introduced a series of environmental protection policies that may affect pollution reduction. This study shortens the time window to avoid interference with these policies. Specifically, we design the following two empirical strategies.

On the one hand, the Chinese government implemented the Air Pollution Prevention and Control Action Plan in July 2013. This policy aimed to promote the national air quality, which may affect pollution reduction. Therefore, this study excludes the samples after 2013 and only retains the samples from 2007 to 2013 for estimation. The results are reported in Columns (1) and (2) in Table 4. On the other hand, considering the impact of China's Action Plan for Prevention and Control of Water Pollution in April 2015 on pollution reduction, this study excludes the samples after 2015 and only retains the samples from 2007 to 2015 for estimation. The results are reported in Columns (3) and (4) of Table 4. Regardless of the time width used, the conclusion that China's TRSEP can promote pollution reduction is robust.

Alternative Estimation Method: The Dynamic GMM

The estimation model used in benchmark regression can identify the effect of TRSEP on the main pollutants, but there may be a reverse-causality relationship between the independent variable and the dependent variable. Besides, changes in pollution

Table 2. Estimation results of benchmark regression.

Variables	(1)	(2)	(3)	(4)
	Polso	Polso	Polcod	Polcod
TRSEP	-0.333*** (-2.914)	-0.279** (-2.737)	-0.121*** (-3.193)	-0.144*** (-3.949)
Lnpergdp	-	0.859 (1.065)	-	1.576*** (3.159)
Fdi	-	-0.001 (-0.338)	-	-0.001 (-0.432)
Financerate	-	0.005 (0.566)	-	0.008 (1.158)
Ind	-	0.007 (0.428)	-	-0.013 (-1.655)
Road	-	0.026*** (3.089)	-	-0.014*** (-3.019)
Energy	-	0.014 (0.915)	-	-0.003 (-0.201)
_cons	13.864*** (73.127)	4.287 (0.517)	13.002*** (199.231)	-1.387 (-0.282)
Year FE	YES	YES	YES	YES
District FE	YES	YES	YES	YES
Obs.	420	420	420	420
R-squared	0.889	0.906	0.850	0.872

Notes: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. The t-values of the variables are shown in parentheses.

emissions in the current period may be influenced by the pollution emissions in the preceding period [31]. Referring to the research of Huang et al. [32], this study constructs the following model for the robustness test.

$$Pollutant_{it} = \alpha_0 + \alpha_1 TRSEP_{it} + \alpha_2 Pollutant_{it-1} + \lambda X_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

where $Pollutant_{it-1}$ is the lagging term of the major pollutant emissions, X_{it} represents a series of control variables, and the other terms are the same as in Equation (1). The results are reported in Table 5. According to the estimation results, the coefficients of TRSEP with Polso and Polcod are significantly negative at the 1% and 5% levels, respectively. This demonstrates that the pollution reduction effect of TRSEP is highly robust.

Table 3. Estimation results of replacing the dependent variable.

Variables	(1)	(2)
	Perpolso	Perpolcod
TRSEP	-4.325 (-0.594)	-10.891** (-2.321)
_cons	-1706.236 (-1.180)	-1720.664*** (-2.824)
Control variables	YES	YES
Year FE	YES	YES
District FE	YES	YES
Obs.	420	420
R-squared	0.731	0.762

Notes: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. The t-values of the variables are shown in parentheses.

Mechanism Analysis

According to the theoretical analysis, implementing the TRSEP may encourage local governments to adopt measures to handle environmental pollution. According to Jiang et al. [33], this study uses mechanism variables as dependent variables and constructs the dynamic GMM model to test the possible mechanisms underlying the pollution reduction effects of the TRSEP:

$$Mechan_{it} = \alpha_0 + \alpha_1 TRSEP_{it} + \alpha_2 Mechan_{it-1} + \lambda X_{it} + \mu_i + \varepsilon_{it} \quad (3)$$

where $Mechan_{it}$ represents mechanism variables, and the other terms are the same as in Equation (2). Specifically, the proportion of government environmental protection expenditure in fiscal expenditure (EPE) is used to measure government environmental protection

Table 4. Estimation results of shortening the time window.

Variables	(1)	(2)	(3)	(4)
	Polso	Polcod	Polso	Polcod
TRSEP	-0.255*** (-4.569)	-0.408*** (-3.519)	-0.263*** (-4.970)	-0.397*** (-3.720)
_cons	13.680*** (3.607)	10.429* (1.988)	11.881*** (3.363)	10.767** (2.657)
Control variables	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
District FE	YES	YES	YES	YES
Obs.	210	210	270	270
R-squared	0.628	0.895	0.689	0.889

Notes: (1) ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. The t-values of the variables are shown in parentheses.

expenditures. The intensity of levying pollution fees and the strength of environmental penalties are measured by the ratio of pollution fees to local fiscal expenditure (PF) and the quantity of environmental administrative penalty per unit GDP (QEAP), respectively. The estimated results of the mechanism analysis are shown in Table 6.

Firstly, TRSEP has a positive relationship with EPE at the 1% significance level. This demonstrates that implementing TRSEP spurs local governments to increase environmental protection expenditures, which can provide sufficient financial support for reducing pollution emissions. Therefore, Hypothesis 1 is proven. Secondly, as shown in Column (2) in Table 6, the relationship between TRSEP and PF appears positive at the 1% significance level, suggesting that implementing the TRSEP increases pollution fees. This finding demonstrates that the government may levy more pollution fees under the pressure of environmental targets, which can increase the pollution costs of producers, thus reducing pollution. Accordingly, Hypothesis 2 is supported. Thirdly, the coefficients of TRSEP with QEAP in Column (3) are positive at the 5% significance level, which indicates that TRSEP can spur local governments to strengthen environmental supervision and penalties. Simply, Hypothesis 3 is verified. Overall, the conclusions of the mechanism analysis indicate that TRSEP can encourage local governments to increase government expenditure on environmental protection, levy environmental fees, and

Table 5. Estimation results of Dynamic GMM.

Variables	(1)	(2)
	Polso	Polcod
TRSEP	-0.173*** (-5.207)	-0.064** (-2.573)
Pollutant $_{t-1}$	0.954*** (48.854)	0.641*** (6.191)
_cons	-3.009** (-2.005)	7.281* (1.937)
Control variables	YES	YES
Obs.	390	390
AR(1)	0.001	0.0004
AR(2)	0.211	0.025

Notes: (1) ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. The t-values of the variables are shown in parentheses. The P values are reported in AR(1) and AR(2).

Table 6. Estimation results of mechanism analysis.

Variables	(1)	(2)	(3)
	EPE	PF	QEAP
TRSEP	0.185*** (2.824)	0.023*** (4.079)	0.136** (2.276)
EPE $_{t-1}$	0.596*** (6.292)	-	-
PF $_{t-1}$	-	0.664*** (45.353)	-
QEAP $_{t-1}$	-	-	0.499*** (6.775)
_cons	2.923 (0.754)	2.039*** (4.793)	0.965 (0.290)
Control variables	YES	YES	YES
Obs.	390	300	330
AR(1)	0.016	0.065	0.010
AR(2)	0.150	0.687	0.645

Notes: (1) ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. The t-values of the variables are shown in parentheses. The P values are reported in AR(1) and AR(2).

strengthen environmental supervision and penalties, thereby reducing pollution.

Considering that TRSEP may have differential effects on the mechanism variables, this study constructs the threshold model to identify the non-linear effects. It is necessary to test its specific form to determine the number of threshold values before setting the threshold model. Specifically, this study uses the bootstrap sampling method to estimate threshold values; the specific results are shown in Table 7.

According to Table 7, the influence of TRSEP on Polcod has no threshold effect when the threshold variables are EPE, PF, and QEAP. However, the influence of TRSEP on Polso has a double threshold effect when the threshold variables are EPE and QEAP. In addition, PF has a single threshold effect. Therefore, the impact of TRSEP on Polso varies across different threshold intervals, specifically through its effects on EPE, PF, and QEAP. According to the research of Li et al. [34], threshold models are introduced to study the non-linear relationship between TRSEP and Polso. The threshold models are described as follows:

$$Polso_{it} = \eta_0 + \lambda X_{it} + \beta_1 TRSEP_{it} \times I(\mathrm{EPE} \leq \gamma_1) + \beta_2 TRSEP_{it} \times I(\gamma_1 < \mathrm{EPE} \leq \gamma_2) + \beta_3 TRSEP_{it} \times I(EPE > \gamma_2) + \varepsilon_{it} \quad (4)$$

$$Polso_{it} = \eta_0 + \lambda X_{it} + \beta_1 TRSEP_{it} \times I(\mathrm{PF} \leq \gamma_1) + \beta_2 TRSEP_{it} \times I(PF > \gamma_1) + \varepsilon_{it} \quad (5)$$

$$Polso_{it} = \eta_0 + \lambda X_{it} + \beta_1 TRSEP_{it} \times I(\mathrm{QEAP} \leq \gamma_1) + \beta_2 TRSEP_{it} \times I(\gamma_1 < \mathrm{QEAP} \leq \gamma_2) + \beta_3 TRSEP_{it} \times I(QEAP > \gamma_2) + \varepsilon_{it} \quad (6)$$

where I represents the indicator function of the threshold model, with I equal to 1 if the condition in parentheses is true; otherwise, I is equal to 0. γ_1 and γ_2 denote the first and second threshold values, respectively.

The results of the threshold model are presented in Table 8; Columns (1)-(3) show the estimation results when threshold variables are EPE, PF, and QEAP, respectively. Firstly, according to Column (1), the proportion of government environmental protection expenditure in fiscal expenditure divides the influence into three intervals. The coefficient of TARSEP×EPE is -0.181 in the first interval. Moreover, the coefficient appears negative at the 1% significance level, with coefficients of -0.287 and -0.446 in the second and third intervals, respectively. Secondly, the ratio of pollution fees to local fiscal expenditure divides the pollution reduction effect of TRSEP into two intervals. As the results show in Column (2), TARSEP×PF has a negative relationship with Polso at the 1% significance level, with coefficients of -0.236 in the first interval and -0.343 in the second interval, respectively. Thirdly, the result of Column (3) indicates that the quantity of environmental administrative penalty per unit GDP divides the effect of TRSEP on Polso into three intervals. In the first interval (QEAP≤7.880), the coefficient is -0.255 at the 1% significance level. In the second interval (7.880<QEAP≤7.952), the coefficient is -0.33 at the 5% significance level, and the coefficient of TRSEP×QEAP is -0.365 at the 1% significance level in the third interval. Furthermore, the estimation coefficient of TRSEP on SO_2 emission has gradually become larger with the increase of threshold variables. Overall, these findings prove that an increase in government environmental protection expenditure, the intensity of pollution fees, and the severity of environmental penalties all amplify the impact of TRSEP on SO_2 emissions.

Heterogeneity Test

Heterogeneity of Environmental Policy

Since environmental governance is highly dependent on administrative policies in China, market-oriented environmental policies have been gradually developed and applied to environmental governance. One of the most representative market-oriented environmental policies is the Carbon Emissions Trading policy, which has taken the lead in pilot projects in some provinces and cities in China. Specifically, Beijing, Tianjin, Shanghai, Guangdong, and Shenzhen launched the ETS pilot in 2013, while Hubei and Chongqing launched the Carbon Emission Trading Scheme (ETS) pilot in 2014. Implementing the ETS pilot may cause differences in environmental governance between different regions

Table 7. Mechanism analysis-the threshold test.

Independent variables	Threshold Variables	Threshold type	F Statistics	Critical values (10%, 5%, 1%)
Ploso	EPE	Double threshold	19.110	(12.371,16.089,19.852)
	PF	Single threshold	34.860	(18.315,22.948,29.501)
	QEAP	Double threshold	52.770	(11.328,13.393,29.746)
Polcod	EPE	No threshold	-	-
	PF	No threshold	-	-
	QEAP	No threshold	-	-

Table 8. Mechanism analysis - the estimation results of the threshold model.

Variables	Threshold Range	Threshold Variables		
		(1) EPE	(2) PF	(3) QEAP
TARSEP×EPE	EPE≤2.137	-0.181 (-1.150)	-	-
	2.137<EPE≤3.311	-0.287*** (-2.770)	-	-
	EPE>3.311	-0.446*** (-3.820)	-	-
TARSEP×PF	PF≤0.080	-	-0.236*** (-5.990)	-
	PF>0.080	-	-0.343*** (-8.980)	-
TARSEP×QEAP	QEAP≤7.880	-	-	-0.255*** (-3.750)
	7.880<QEAP≤7.952	-	-	-0.330** (-2.600)
	QEAP>7.952	-	-	-0.365*** (-5.260)
_cons	-	24.712*** (16.090)	23.635*** (25.580)	26.197*** (16.880)
Control variables	-	YES	YES	YES
Obs.	-	420	330	360
R-squared	-	0.274	0.160	0.176

Notes: (1) ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. The t-values of the variables are shown in parentheses.

and then cause heterogeneity in pollution reduction. This study divides the regions into ETS groups and non-ETS groups for estimation, and the result is reported in Table 9.

As shown in Columns (1) and (2) of Table 9, the estimated coefficients are significantly negative whether the dependent variables are Polso or Polcod. According to the results of Columns (3) and (4), the coefficients of TRSEP and Polcod are negative at the 10% significance level, while there is no significant relationship between TRSEP and Polso. The above conclusions prove that implementing TRSEP has a more

Table 9. Heterogeneity of environmental policy.

Variables	Provinces in the carbon emission trading scheme pilot districts		Provinces in the Non-carbon emission trading schemes pilot districts	
	(1) Polso	(2) Polcod	(3) Polso	(4) Polcod
TRSEP	-0.250*** (-4.077)	-0.132** (-3.667)	-0.075 (-0.540)	-0.207* (-1.788)
_cons	9.417 (0.794)	22.592** (3.145)	11.802* (1.833)	-6.854* (-1.721)
Control variables	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
District FE	YES	YES	YES	YES
Obs.	84	84	336	336
R-squared	0.964	0.887	0.931	0.891

Notes: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. The t-values of the variables are shown in parentheses.

significant negative impact on pollution emissions for provinces implementing the ETS pilot. This indicates that the combination of administrative and market-oriented institutions may complement each other to promote pollution reduction in the environmental governance process in China. Therefore, it is necessary to coordinate the construction of administrative and market-oriented environmental institutions to provide institutional guarantees for winning the battle against pollution prevention and control.

Heterogeneity Effect of Pollutant Categories

Considering the multi-level governance structure and the objective tasks in China, TRSEP may have heterogeneous effects for different types of pollutants. Specifically, the multi-level government structure in China determines that the total constraint targets of major pollutants are transmitted from the top (central government) to the bottom (local government), which may cause the attenuation of governance efficiency in the government's decision-making behavior during the hierarchical transmission. Under the dual pressure of development and environmental protection, local governments may pay more attention to obligatory targets and neglect non-obligatory targets to alleviate the pressure of top-down goal assessment. Hence, local governments may allocate more resources to achieving obligatory targets but fewer resources to other types of pollution [35]. However, these pollutants may also affect the overall quality of the ecological environment. Therefore, the local governments may focus on the obligatory targets of major pollutants while implementing TRSEP, which may not significantly affect non-obligatory pollution emissions.

To identify the heterogeneity effects of TRSEP on obligatory and non-obligatory pollutants, this study uses exhaust gas and wastewater emissions to replace the emissions of SO_2 and COD. Specifically, this study chooses the logarithmic values of emissions of industrial waste gas and industrial sewage of each province as the dependent variables and introduces these variables into the model (1). The estimated results are reported in Columns (1) and (2) of Table 10. Furthermore, per capita industrial waste gas emissions and industrial sewage emissions are set as dependent variables. The detailed results are shown in Columns (3) and (4) of Table 10.

The results indicate that the estimated coefficients of TRSEP are negative but not significant when the dependent variables are Polg, Polw, Polgper, and Polwper. This demonstrates that the effect of TRSEP on different types of pollutants is heterogeneous. Specifically, the TRSEP cannot significantly promote the emission reduction of non-obligatory pollutants. Considering the Chinese multi-level governance structure and the objective targets faced by the government, the effectiveness of environmental governance is gradually declining, encouraging local governments to adopt differentiated governance strategies. In other words, local governments prioritize achieving obligatory targets and do not attach enough importance to regulating the pollution of non-obligatory targets, resulting in a loss of effectiveness for this institution. This conclusion provides clear policy implications for innovating the responsibility mechanism and optimizing the contents of environmental protection targets.

Extended Analysis

With the continuous deepening of green and sustainable development, promoting economic and social green transformation has become an important goal pursued by local governments in China. Implementing TRSEP may promote the green transformation of economic structure and green economic growth.

Existing studies indicate that local governments usually strengthen environmental supervision by raising environmental administrative penalties and pollution

Table 10. Heterogeneity effect of pollutant categories.

Variables	(1)	(2)	(3)	(4)
	Polg	Polw	Polgper	Polwper
TRSEP	-0.067 (-1.566)	-0.080 (-0.766)	-0.303 (-1.438)	-1.994 (-0.911)
_cons	-0.110 (-0.012)	17.852** (2.352)	4.780 (0.114)	147.712 (1.325)
Control variables	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
District FE	YES	YES	YES	YES
Obs.	270	270	270	270
R-squared	0.689	0.145	0.411	0.262

Notes: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. The t-values of the variables are shown in parentheses.

Table 11. The estimation result of green economic development effect.

Variables	(1)	(2)
	Gee	Gee
TRSEP	0.052** (2.246)	0.049** (2.425)
_cons	0.260*** (6.519)	3.847* (1.758)
Control variables	NO	YES
Year FE	YES	YES
District FE	YES	YES
Obs.	420	420
R-squared	0.303	0.348

Notes: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. The t-values of the variables are shown in parentheses.

discharge fees to eliminate excess production capacity and promote pollution reduction. Meanwhile, local governments also establish new capital investment policies and encourage green technological innovation through environmental subsidies, thus achieving a win-win situation for the environment and economy. In addition, the "Pollution Heaven hypothesis" indicates that the areas with looser environmental regulation may become a "heaven" for pollution-intensive enterprises [36]. Meanwhile, the "pollution heaven" effect occurs not only between different countries but also in different regions within a country. Different environmental regulation intensities in different regions may lead to polluting enterprises transferring to areas with loose environmental regulations and less effective utilization of foreign direct investment [37, 38].

With the implementation of TRSEP, local governments may inevitably adopt strict environmental regulatory measures, such as strengthening environmental administrative penalties, pollutant discharge taxes, etc. The tightening of environmental regulation increases the costs of polluting enterprises in the short term, which may force them to improve production technologies, reduce production, enhance pollution control capacity, and even move to regions with lower environmental regulation. Meanwhile, the government's fiscal expenditures and investments will gradually transfer to the clean industry to promote industrial structure upgrading. Therefore, implementing TRSEP may guide the green transformation of industries and promote green economic growth while reducing pollution.

To identify the effect of TRSEP on green economic development, this study constructs an indicator to measure the economic green development level. Generally, the resource and environmental indicators should be included in the indicator system of green economic development. Specifically, this study uses green economic efficiency to measure the green economic development of each province. Green economic efficiency (Gee) is a comprehensive indicator of economic growth and environmental development. Also, it is the economic benefits under environmental and resource constraints [39]. The higher the value of Gee, the higher the level of green development. Gee's calculation process is presented in Appendix B. Gee is introduced as the dependent variable to measure the effect of TRSEP on green economic development. The results are presented in Table 11. Column (1) shows the regression results with fixed effects, and Column (2) presents those with fixed effects and control variables.

As shown in Table 11, TRSEP is significantly positive regardless of whether the control variables are introduced. Specifically, the TRSEP significantly improves the Gee by 0.049 with all control variables. When the fixed effects and control variables are controlled, TRSEP has a significant positive impact on Gee at the 5% significance level, indicating that implementing TRSEP promotes green economic development. This finding provides empirical evidence that China's TRSEP reduces the proportion of polluting industries in the regional industrial structure, encouraging the development of environmentally friendly industries, such as knowledge-intensive industries, and promoting improved green economic efficiency.

Conclusions

Based on the panel data of 30 provinces within China from 2007 to 2020, this paper identifies the pollution reduction effect and mechanism of TRSEP and then analyzes its impact on the green growth of the regional economy. Compared to the existing literature, this study is unique in that it contributes to the existing research in three ways. First, this study identifies the mechanism regarding how TRSEP affects pollution reduction, which enriches the research on the analysis of TRSEP. The existing research considered that TRSEP could motivate local governments to take a series of measures to achieve expected targets [10]. However, which government measures will be motivated by TRSEP to realize pollution reduction has not been empirically verified. This study proves that TRSEP can encourage local governments to increase environmental protection expenditure, levy pollution fees, and strengthen environmental administrative penalties to control pollution emissions. Second, this study analyses the effect of TRSEP on regional green economic growth. Related studies examining the environmental targets will constrain GDP growth goals [2] and reduce pollutant emissions [13, 17, 18], but the green economic effect of TRSEP has not been tested yet. Under the constrained targets of TRSEP, environmental governance measures may promote regional green economic growth while reducing pollution. This study provides evidence that TRSEP can improve green economic growth, which demonstrates that the effects of pollution reduction are sustainable in the long term. Third, this study constructs a specific index to measure the constraint intensity of TRSEP, which enriches research on the quantitative analysis of TRSEP. The current research used single emission reduction targets [2] or dummy variables [8, 9] to measure the constraint strength of TRSEP. In particular, multiple pollutant obligatory targets were introduced to TRSEP during China's 11^{th} Five-Year Plan period; using only one target or dummy variable cannot comprehensively quantify the TRSEP. Therefore, considering the data availability and multiple pollutant constraint targets, this study constructs a specific index to measure the constraint intensity of TRSEP.

The main conclusions are as follows. (1) The implementation of TRSEP spurs the emission reduction of obligatory pollutants such as SO_2 and COD, and this conclusion is still valid after a series of robustness tests. (2) The mechanism test indicates that TRSEP can influence governments' behavior to reduce pollution by increasing environmental protection expenditure, levying pollution fees, and environmentally strengthening administrative penalties. In addition, the effect of TRSEP on SO_2 emission is strengthened with the enhancement of government environmental protection expenditure, the intensity of levying pollution fees, and the strength of environmental penalties. (3) The heterogeneity analysis shows that the pollution reduction effect of TRSEP is more significant for provinces in the ETS pilots. Meanwhile, TRSEP significantly differs in the emission reduction effects of obligatory and non-obligatory pollutants. Specifically, the emission reduction effect of the TRSEP is not significant for non-obligatory pollutants such as industrial waste gas and industrial sewage. (4) Implementing TRSEP is conducive to improving green economic efficiency, thus promoting regional sustainable economic development.

Implications

Based on the conclusions, this paper proposes several policy implications for promoting government pollution control and green transformation. (1) Decision-making departments need to improve the target setting and assessment contents from top to bottom and gradually build a complete target assessment and constraints system, which includes air, water, soil pollution, carbon emissions intensity, etc. Additionally, the intensity of TRSEP should be improved to incentivize local governments' pollution control behavior through strict environmental protection target constraints. (2) Local governments should promote pollution control and establish a long-term cooperation mechanism for environmental governance between regions. On the one hand, utilizing the technological innovation advantages of the eastern region promotes the diffusion of green and low-carbon technologies from the eastern region to the central and western regions. On the other hand, the transfer payments for environmental protection in the central and western regions and national ecological functional areas should be strengthened to realize coordinated governance and green transformation at the national level. (3) Governments should gradually construct different types of environmental governance systems and promote the synergy and complementarity between different environmental policies. Specifically, governments should make full use of the market environmental institutions, such as carbon emissions trading, to form the superposition of governments and markets and provide institutional guarantees for winning the battle of pollution prevention. (4) Strengthening the implementation of the TRSEP through central environmental inspections, special funds support, and other incentive systems to motivate the governance behavior of pollution control. Furthermore, local governments should not only increase government expenditures on environmental protection and levy environmental fees but also strengthen environmental supervision and penalties to constrain pollution emissions to promote regional green economic development.

Research Limitations

There are still some limitations of this study, which may be further expanded in the future. In this paper, quantifying the constraint intensity of TRSEP has always been difficult. Due to the limitation of statistical standards and data continuity, this study takes COD and SO_2 emission control targets as core indicators to calculate the constraint intensity of TRSEP. Suppose the limitations of data continuity and statistical standards are broken. In this case, energy-saving targets, nitrogen oxide emission control targets, and other environmental targets may be included in calculating the constraint intensity of TRSEP, thereby further enriching the quantitative analysis of TRSEP.

Appendices

Apendix can be found at the link:
https://www.pjoes.com/SuppFile/201935/1/

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Conflicts of Interest

The authors declare no conflict of interest.

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