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Environmental Protection Tax and China's Economic Growth: Boost or Slowdown?

Qing Zhao * and Chih-Hung Yuan *

School of Economics and Commerce, University of Electronic Science and Technology of China, Zhongshan Institute, Zhongshan 528402, China

* Correspondence: zhaoguoqing1977@163.com (Q.Z.); ialexyuan@gmail.com (C.-H.Y.)

Abstract: This paper explores the impact of China's environmental protection tax reform on economic growth through empirical research. Using the "fee to tax" policy implemented in China in 2018 as a natural experiment, the analysis is conducted using a strengthened double-difference (DID) model. It is found that environmental protection tax reform has a significant positive impact on regional economic growth, and this conclusion still holds after several robustness tests. In order to explore the mechanism of environmental protection tax in-depth, this paper analyzes the three dimensions of science and technology innovation investment, foreign direct investment, and tax administration intensity. The results show that environmental protection tax does not promote technological innovation of enterprises as expected, but may instead inhibit R&D and innovation activities by increasing the cost pressure on enterprises. The positive impact of environmental protection tax on economic growth is mainly realized by increasing the intensity of tax administration. Furthermore, this paper analyzes the heterogeneity in urban geographic locations and administrative levels, finding that environmental protection taxes have a significant positive effect on economic growth in central and northeastern regions and in cities with lower administrative levels, while they have a negative effect in the eastern region and in cities with higher administrative levels.

Keywords: environmental protection tax; economic growth; scientific and technological innovation; foreign direct investment; tax administration intensity

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1. Introduction

In the modernization of China, the concept of realizing the harmonious coexistence between man and nature has been given a core position. In recent years, the Chinese government has promoted the strategy of driving green, high-quality, and sustainable development to the national level, and actively advocated and practiced the development concept of "lucid waters and lush mountains are invaluable assets". In environmental pollution control, China spends equivalent to 10% of its gross domestic product (GDP) every year, leading among emerging economies in Asia and the world, reflecting China's firm will and commitment to strengthening ecological and environmental protection and deepening pollution prevention and control.

Since 1982, when The State Council promulgated the "Interim Measures for the Collection of Sewage Fees", the pollutant discharge fee system has been gradually established and improved in China. In 2003, the implementation of the "Regulations on the Administration of the Collection and Use of Sewage Fees" further optimized the collection and management of pollutant discharge fees. However, due to the lack of collection intensity and the low charging standard, the environmental governance effect of the actual implementation of the sewage discharge fee system is not satisfactory. In 2013, the Third Plenary Session of the 18th CPC Central Committee proposed the reform direction of changing environmental protection fees into taxes, aiming at strengthening environmental pollution control.

On 25 December 2016, the "Environmental Protection Tax Law of the People's Republic of China" was deliberated and adopted by the Standing Committee of the National

People's Congress, and officially came into force on 1 January 2018, which marked the formal establishment of China's environmental protection tax system. This reform not only realizes the smooth transition of tax burden, maintains the continuity with the original sewage discharge fee system, and avoids the drastic fluctuations of enterprise costs, but also enhances the strictness of legislation, and strengthens the awareness of environmental protection and pollution control responsibility of enterprises. In particular, the environmental protection tax law increases the flexibility of taxation, allowing local governments to adjust their tax rates according to the actual situation, and giving them greater autonomy. Since the implementation of the "Environmental Protection Tax Law", different regions have adopted differentiated tax strategies according to their local environmental governance needs and economic development level. Such regional differences provide valuable opportunities for "natural experiments" for economic research and help to deeply evaluate the policy effect of the environmental protection tax.

The reform of the environmental protection tax is based on the "double dividend" hypothesis, which aims to achieve a win-win situation of environmental benefits and economic benefits. To evaluate whether China's environmental protection tax policy can achieve a "green dividend" and a "blue dividend" has become an important standard to measure the effectiveness of the policy. In the context of globalization, China, as the world's largest developing country, has profound impacts on both its domestic development and the global economy and environmental governance through its economic policies and environmental management practices. The choice of China as the subject of this study is not only due to its significant position in the global economy but also because of its pioneering efforts in environmental protection tax reform, which provides valuable experience and insights for environmental policies worldwide. By conducting an in-depth analysis of the impact of China's environmental protection tax reform on economic growth, this study aims to uncover the complex relationship between environmental policies and economic development, offering theoretical support and policy references for the coordinated development of environmental protection and economic growth on a global scale. This paper uses the "fee-to-tax" policy implemented in China in 2018 as a natural experiment and employs an enhanced Difference-in-Differences (DID) model for empirical analysis. The analysis reveals that the reform of environmental protection taxes has a significantly positive effect on regional economic growth. To further explore the mechanisms of environmental protection taxes, the paper investigates three dimensions: investment in scientific and technological innovation, foreign direct investment, and the intensity of tax administration. The study finds that environmental protection taxes do not promote corporate technological innovation as expected; instead, they may suppress R&D and innovation activities by increasing the cost burden on companies. The positive impact of environmental protection taxes on economic growth is primarily realized through the enhancement of tax administration intensity. Additionally, this paper examines the heterogeneity in terms of urban geographic locations and administrative levels and finds that environmental protection taxes have a more significant impact on economic growth in central and northeastern regions and in cities with lower administrative levels, while they have a negative effect in the eastern region and in cities with higher administrative levels.

The primary contribution of this paper lies in filling the gap in the existing literature regarding the impact of China's environmental protection tax reform on economic growth. By employing the Difference-in-Differences (DID) model, the study offers a new perspective for assessing the economic effects of environmental policies. Compared to existing literature, the innovations of this paper are reflected in the following aspects:

This paper selects China's "fee-to-tax" policy implemented in 2018 as the research subject, marking a significant transformation in China's environmental policies and providing a unique case study for environmental policies both in China and globally. As Jaffe and Palmer [1] pointed out, there is a complex relationship between environmental regulation and innovation. By focusing on the "fee-to-tax" policy, this paper can more accurately assess the impact of environmental protection taxes on economic growth. This perspective

complements existing literature on the micro-level impacts, such as Jin et al.'s [2] analysis of corporate performance, Liu and Xiao's [3] study on the impact of innovation, and Sun and Zhang's [4–6] discussion on productivity. The research not only extends these micro-level discussions but also considers them in the context of macroeconomic growth.

Another of the notable innovations of this study lies in its in-depth multidimensional analysis of the mechanisms through which environmental protection taxes function. Transcending the scope of traditional environmental economics research, this paper specifically focuses on the indirect effects of environmental policies on economic growth and meticulously examines three key economic areas: investment in scientific and technological innovation, foreign direct investment, and the intensity of tax administration. Through the meticulously constructed analytical framework, this paper not only reveals how environmental protection taxes impact economic growth through these core economic activities but also offers unique insights into the complex interplay between environmental protection taxes and economic growth. This contribution not only enriches the theory of the economic effects of environmental policies but also provides new perspectives and ideas for formulating more effective environmental economic policies.

This study delves into the regional heterogeneity of the impact of China's environmental protection tax on economic growth, taking into account the differences in economic development levels and environmental carrying capacities across various regions within the country. Through meticulous regional analysis, this paper reveals the varying influences of the environmental protection tax on economic growth in different areas, indicating that the policy effects are not uniform across all regions. These findings on regional disparity provide empirical evidence for the formulation and adjustment of region-specific environmental policies, emphasizing the need for environmental policies to be tailored to the specific conditions of each region. The research results support the geographical dependence of environmental policy implementation effects, highlighting the importance of flexibility and differentiation in the design of environmental policies. Through this analysis, this paper offers a new perspective for understanding and optimizing environmental protection tax policies, aiding in the precise targeting and maximization of policy effects.

The structure of this paper is as follows: the second part starts with the literature review; the third part carries the theoretical analysis and the assumptions of this paper; the fourth part details the research design and the data used; and the fifth part presents the results of empirical analysis and the research findings; the sixth part comes to the conclusions and targeted policy suggestions.

2. Literature Review

In the course of economic development in many countries, especially in developed countries, the economic growth model is often at the expense of the environment. In view of the public product attribute of environmental resources, as well as the inherent negative externalities of environmental problems and the opportunistic behavior of microeconomic subjects, it is difficult to effectively solve environmental problems only by the market mechanism. Therefore, environmental regulation is widely regarded as a key tool to correct market failure. However, whether the current environmental regulation can achieve an effective balance between economic growth and environmental protection is still a question worth discussing.

The strict environmental regulation is widely recognized in academia for its ability to improve the ecological environment and the health conditions of residents [7–10]. However, there is still significant divergence in the conclusions of relevant studies regarding how environmental regulation affects economic growth. Existing literature largely revolves around the "Compliance Cost Theory" and the "Porter Hypothesis". Specifically, first, the "Compliance Cost Theory" argues that strict environmental regulations impose new constraints on corporate production decisions, increasing direct and indirect production costs for businesses, limiting their investment in innovation, and leading to efficiency losses in production, management, and sales, and thus being detrimental to the enhancement of

corporate competitiveness. In light of this, some studies suggest that strict environmental regulations will reduce a region's economic competitive strength, which is not conducive to the improvement of economic development levels. Gray [11] found that strict environmental regulations increase the production costs for businesses, which include not only direct compliance costs but also indirect costs associated with regulation, such as technological upgrades and process adjustments. Christiansen and Haveman [12], after analyzing data from 450 manufacturing industries between 1958 and 1978, discovered a significant negative correlation between these regulations and productivity growth. Levinsohn and Petrin [13] found that environmental regulations, by increasing compliance costs for businesses, alter production decisions and production technology choices, thereby affecting overall production efficiency. In the Chinese context, the research by Li et al. [14] pointed out that environmental regulation may inhibit economic growth in some areas dominated by heavy industry, indicating that environmental regulation may become a constraint on economic growth. Cai and Ye [15] also found that China's new environmental law suppressed corporate total factor productivity (TFP), and the impact lasted for two years. That is to say, if the "Compliance Cost Theory" holds true, then there exists a "trade-off dilemma" between environmental protection and economic growth.

The positive impact argument that environmental regulation can have a positive impact on economic growth is strongly supported by the "Porter hypothesis" [16], which claims that properly designed environmental policies can stimulate innovation, not only improve production efficiency, but may also reduce long-term costs, a phenomenon known as the "innovation compensation effect". This effect includes technological innovation and product innovation, which helps to reduce the cost of enterprises, promote technology communication and efficiency improvement, promote the optimization and upgrading of enterprises and industrial structure, and enhance market competitiveness.

Scholars supporting the "Porter Hypothesis" provide evidence through empirical research. Jaffe et al. [1] showed a positive correlation between environmental regulation and corporate investment in R&D, providing early support for Porter's hypothesis. Hamamoto [17] investigated the relationship between environmental expenditure and innovative activities in Japan's manufacturing industry, with results showing that increased R&D investment due to environmental regulation significantly boosted total factor productivity growth. Franco and Marin [18] found that appropriate energy tax policies can encourage enterprises to adopt more efficient energy usage methods and clean technologies, thereby enhancing the overall economic innovation capacity and productivity. Jorge et al. [19] focused on small and medium-sized enterprises in Spain, analyzing the interactive relationship between environmental regulation and corporate competitiveness, and also found that environmental regulation could directly and significantly enhance the competitiveness of small and medium-sized enterprises. This implies that the "innovation effect" of environmental regulation not only reduces energy input and pollution emissions but also improves enterprise productivity through production method improvements and technological upgrades [20–22]. Research on the impact of environmental policy on economic growth is a key area in academic studies. Based on the R&D-driven endogenous growth model, Aghion and Tournemaine [23] found that environmental taxes promote economic growth through health effects and R&D effects. Dao and Edenhofer [24] discovered that environmental taxes promote the accumulation of physical capital by reducing pollution and increasing life expectancy. Yang et al. [25] found that environmental regulations significantly promoted innovation capability and an increase in R&D investment in Taiwan's manufacturing industry, and appropriate environmental regulation can encourage enterprises to enhance environmental protection investment and effectively drive regional economic growth. In the field of research on China's environmental protection tax, some scholars have observed that this tax has promoted the expansion of corporate investment [26], encouraged corporate green innovation [3], enhanced productivity [6], and improved company performance at the micro level [2,27,28], while at the macro level, it has contributed to the enhancement of the overall economic total factor productivity [29].

To sum up, although the existing studies have made several key findings, there is no consensus on environmental regulations among different countries and the diversity of environmental regulations, sample selection, and the diversity of research methods [30]. Especially in the role of market-oriented economic incentive mechanisms in environmental policy, related research is still relatively scarce. In view of this, the environmental protection tax implemented in China in 2018 was taken as the research object to discuss profoundly its impact on economic growth and its action mechanism, aiming to provide a new perspective and supplement the existing literature.

3. Policy Background and Theoretical Analysis

3.1. Policy Background

The implementation of China's environmental protection tax marks a major change in the country's environmental governance system. Since 1 July 2003, China began to levy sewage charges on dischargers to control pollution emissions by economic means. However, with the acceleration of industrialization and urbanization, environmental pollution problems have become increasingly prominent, and the original sewage fee system has gradually revealed problems such as narrow scope of collection, insufficient rigidity of law enforcement, and interference by local governments, which have seriously harmed the ecological environment and social welfare. In order to address environmental challenges more effectively, on 1 January 2018, the Law of the People's Republic of China on Environmental Protection Tax was formally implemented, replacing the original sewage fee system. The core objective of this reform is to protect and improve environmental quality, reduce pollutant emissions, and promote the construction of an ecological civilization. The implementation of the environmental protection tax not only raises the levy standards for wastewater and exhaust gas, such as the levy standard for sulfur dioxide in Beijing, which has been raised from RMB 10/kg to RMB 12/kg, but also standardizes the tax collection and management procedures, increases the tax reduction and exemption brackets, and improves the incentive effect of the policy.

The policy features of the environmental protection tax are reflected in the enhancement of its legal status, the improvement of tax standards, the increase in tax relief incentives, the standardization of collection and management, the setting of upper limits for collection standards, the incentives for local fiscal revenues, the embodiment of regional disparities, and the promotion of industrial restructuring. As a statutory tax, the legal status of the environmental protection tax has been significantly upgraded from the previous sewage charges, enhancing the authority and rigidity of law enforcement. Compared with sewage charges, environmental protection tax generally raises the collection standard of pollutants, which helps strengthen the economic incentives for pollution reduction. In addition, the environmental protection tax has increased the tax relief bracket for enterprises to reduce emissions, and gives greater tax concessions to enterprises that take effective emission reduction measures, in order to incentivize enterprises to improve environmental protection. The environmental protection tax has increased the upper limit of the collection standard, while the national standard for sewage charges only provides a lower limit, providing local governments with greater autonomy and flexibility. The environmental protection tax is collected as local revenue, a change designed to incentivize local governments to strengthen environmental supervision and improve the efficiency and effectiveness of tax use. The environmental protection tax allows different cities to set different levy standards and tax rates according to their own environmental carrying capacity and level of economic development, reflecting the regional differentiation of the policy [30]. Together, these policy features constitute the framework of the environmental protection tax, which aims to promote environmental protection through market-based means and achieve a win-win situation in terms of environmental quality improvement and economic development.

3.2. Theoretical Mechanisms

Under budgetary constraints, firms may reduce productive investment in order to comply with environmental regulations, and this "compliance cost" effect may inhibit economic growth. One study showed that the implementation of China's Clean Air Initiative led to a significant decline in manufacturing output of 6.7% in the first two years, and that stronger environmental regulations significantly reduced output in China. In contrast, however, the Porter Hypothesis suggests that moderate environmental regulations can stimulate technological innovation and reduce pollutant emissions. Environmental regulations can induce firms to engage in green innovation and promote the research and development of green technologies. In order to cope with the long-term environmental costs, enterprises may carry out equipment upgrades and modifications to improve their core competitiveness, and their "innovation compensation" effect may partially or fully offset the "compliance costs", which may improve productivity and promote economic growth through technological progress.

In addition, environmental regulations, especially the implementation of environmental protection taxes, have a positive impact on economic growth by attracting foreign direct investment (FDI). Environmental regulations enhance China's international image and market confidence, demonstrate the government's commitment to sustainable development, and attract foreign investors seeking environmentally friendly solutions. The advanced technology and management experience brought by FDI helps local industries upgrade their technology and productivity. The environmental protection tax incentivizes local enterprises to raise their environmental standards, attracts investors with stringent environmental requirements, and promotes the development of the environmental protection industry. These investments increase employment opportunities, raise residents' income and consumption levels, and further stimulate economic growth. FDI also promotes the optimization and upgrading of the industrial structure, increases government revenues, and provides more resources for environmental protection and the construction of public facilities.

Finally, the contribution of environmental regulation, especially the introduction of environmental protection tax, to economic growth is also reflected in the improved efficiency of tax collection and administration. With the implementation of environmental protection tax, the government must establish and improve an effective tax collection and administration system to ensure the smooth implementation of tax policies. This process involves not only the formulation and implementation of tax regulations, but also the supervision of enterprises, the transparency of tax information, and the optimization of tax services. By improving the efficiency and transparency of tax collection and administration, the government is able to monitor and collect tax revenue more accurately and reduce tax evasion and leakage, thereby increasing fiscal revenue and providing more financial support for public services and environmental governance. At the same time, an efficient and transparent tax collection and administration system can increase enterprises' trust in tax policies, reduce their compliance costs, and enhance their willingness to invest. With clear tax burdens and incentives, enterprises are better able to plan their financial and operational activities and make long-term investments and expansions, thereby promoting economic growth.

4. Study Design and Data Description

4.1. Model Setting

The impact of environmental protection tax reform on regional economic growth was examined in the paper, with the model set as follows:

$$\mathrm{LnGDP}_{it} = \alpha_0 + \beta_1 \mathrm{IntDID}_{it} + \Phi \mathrm{Controls}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In this paper, the natural logarithm (lnGDP_{it}) of regional GDP was used as a key measure of regional economic growth, which effectively handles the nonlinear features of

the original data by taking them logarithmically and enhances the explanatory power and prediction accuracy of the model. The core explanatory variable of this paper is the intensity interaction term $IntDID_{it}$, which represents the potential impact on economic growth of the environmental protection tax reform implemented in 2018. The introduction of an environmental protection tax is in sharp contrast with the previous sewage discharge fee system in terms of legal status, policy objectives, emission reduction incentive mechanism, collection subject, and income distribution. Although some provinces and cities have not adjusted the tax rate, all cities have been driven by unified environmental supervision pressure and preferential policies for emission reduction, thus jointly experiencing the comprehensive impact of policy reform.

In order to clearly distinguish between the experimental group and the control group, the Intensity Difference-in-Differences (IntDID) model was constructed. The policy dummy variable Treati and the time dummy variable Timet were determined based on the change in levy standards for sulfur dioxide emissions. There will be no significant difference between the division of the experimental group and the control group based on the change in sulfur dioxide and nitrogen oxide or the change in chemical oxygen demand and ammonia nitrogen. This is because the collection standards of these pollutants are consistent, thus ensuring the consistency and comparability of the grouping in the study.

Specifically, we marked the cities with sulfur dioxide emission standards above the sample median as $Treat_i = 1$, and those below the median as = $Treat_i = 0$; meanwhile, the time in 2018 and later was marked as = $Time_t = 1$, and the previous time was marked as $Time_t = 0$. Through the product of the two dummy variables, the intensity interaction term $IntDID_{it} = Treat_i \times Time_t$ was obtained to assess the net effect of the environmental protection tax reform on economic growth. Here, i represents the city and t represents the time; λ_t is the fixed effect of year; μ_i is the urban fixed effect; and ε_{it} represents the error term.

Four key control variables were selected to comprehensively assess the multidimensional factors of economic growth: the number of regional resident population to reflect the positive effect of the labor market size and demographic dividend; the logarithm value of actual fixed asset investment to control the contribution of investment activities to economic growth; the balance of bank deposits and loans at the end of the year was logarithmic to measure the promotion effect of financial development level on economic growth; and the financial self-sufficiency rate, which reflects the financial capacity of local government and its potential impact on economic growth. These carefully selected control variables were designed to enhance the robustness of our empirical analysis results, ensuring an in-depth understanding of the complexity of economic growth from multiple perspectives. See Table 1 for the specific variable design.

Table 1. Major Variables and Definitions.

Variables	Meaning	Definition
LnGDP	Economic growth	Logarithm of per capita GDP
Time	Time virtual variable	Equal to 0 before 2018, and 1 after
Treat	Policy virtual variable	1 for areas with collection criteria greater than the median and 0 for less than the median
IntDID	Intensity interaction term	Time virtual variable × Policy virtual variable
Population	Population	The resident population was logarithmic
Finance	Financial development	The balance of deposits and loans of financial institutions was logarithmic
Fiscal	Fiscal capability	The general public budget revenue was divided by the general public budget expenditure
Investment	Investment level	The fixed asset investment was logarithmic

4.2. Data Description

Based on statistics from 2013 to 2022, information was extracted from the "Urban Statistical Yearbook", "Regional Statistical Yearbook", and EPS database. To ensure the accuracy and robustness of the analysis, the data were strictly preprocessed: including 1% and 99% of the data after grouping to eliminate extreme values, and logarithmically calculating the absolute numerical data to reduce the impact of fluctuations and heteroscedasticity. All empirical analyses were performed through Stata 17.1 software to ensure the professionalism and precision of the results. Descriptive statistics of the relevant variables are shown in Table 2. LnGDP measures the level of economic growth in the region, with an average value of 10.846 and a standard deviation of 0.539, indicating a significant variation in the economic growth levels among different cities. Treat indicates whether the city's sulfur dioxide emission standard is higher than the median of the sample, coded as 1 if it is, and 0 otherwise. The average value of 0.822 suggests that the majority of the sample cities have standards above the median. IntDIDI is the product of policy and time dummy variables, used to assess the net effect of environmental tax reform on economic growth, with an average value of 0.322, indicating that a considerable portion of the cities in the sample were affected after the implementation of the policy.

Table 2. Descriptive Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
LnGDP	2900	10.846	0.539	8.036	11.982
Time	2900	0.500	0.500	0	1
Treat	2900	0.822	0.382	0	1
IntDID	2900	0.322	0.467	0	1
Population	2900	5.876	0.702	3.807	7.193
Investment	2900	7.229	0.943	0	9.034
Finance	2900	17.586	1.085	13.981	20.433
Fiscal	2900	0.450	0.227	0.057	3.256

5. Empirical Results Analysis

5.1. Benchmark Regression

Table 3 provides the results of the regression analysis of the benchmark model, which allows us to preliminarily assess the impact of environmental protection tax reform on the economic effects. In column (1), the underlying model was constructed, which only included the fixed effects of city and time, providing a solid foundation for subsequent analysis. In column (2), to enhance the robustness of the model and control potential missing variables, a series of key control variables was further introduced, including population size, fixed asset investment, financial development level, and fiscal self-sufficiency rate, so as to comprehensively consider other factors that may affect economic growth.

Table 3. Benchmark Regression.

Models	(1) LnGDP	(2) LnGDP
IntDID	0.027 ***	0.025 **
	(2.60)	(2.37)
Population		0.012
		(0.54)
Investment		0.140 ***
		(3.74)
Finance		0.216 ***
		(3.41)
Fiscal		0.366 ***
		(6.88)
Constant	0.067 ***	5.788 ***

Table 3. *Cont.*

Models	(1) LnGDP	(2) LnGDP
Year FE	Yes	Yes
City FE	Yes	Yes
N	2900	2900
R2	0.931	0.957

Notes: *t*-statistics in parentheses, ** $p < 0.05$, *** $p < 0.01$.

The results of the regression analysis showed that the estimated coefficient of the core explanatory variable DID was significantly positive under the setting of both models, and remained significant at the confidence level of 1% or 5%, which provided us with strong statistical evidence and supported that the reform of environmental protection tax has a positive role in promoting regional economic development. For control variables, the coefficient of population size did not show significance, which may indicate that the direct impact of population size on economic growth was more limited over the sample period examined. In contrast, the coefficients of fixed asset investment, financial development level, and fiscal self-sufficiency were all significantly positive at the confidence level of 1%, highlighting the key role of these factors in promoting economic growth.

5.2. Parallel Trend Test

In the benchmark regression analysis presented in Table 3, it is found that the environmental protection tax policy had a significant positive effect on China's economic growth. To further verify whether this effect indeed originated from the implementation of environmental protection tax policy, a parallel trend test was conducted. The rationality of the parallel trend test was based on the assumption that the experimental and control groups should show parallel trends before the policy, and significant differences between the two groups after the policy. In this paper, the parallel trend hypothesis was tested using event studies. Figure 1 shows the results of parallel trends of the impact of environmental protection tax reform on economic growth. The analysis results showed that before the policy implementation, the trend of the economic growth rate fluctuated around the zero value, and the 95% confidence interval contained zero, which indicates that the trend of the experimental group and the control group was consistent before the policy was implemented. However, in the third year after the implementation of the policy, a significant upward trend of regional economic growth rate was observed, indicating that the environmental protection tax policy had a positive promotion effect on economic growth after a certain lag period, satisfying the parallel trend assumption of DID method requirements.

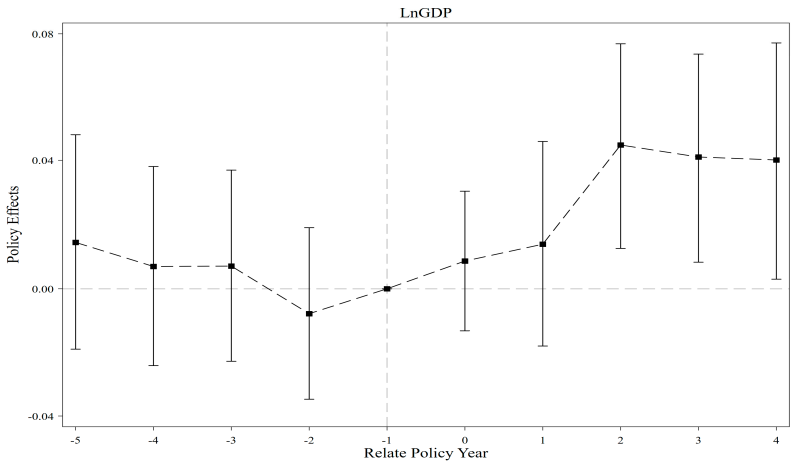

Figure 1. Parallel trend test.

5.3. Robustness Test

To enhance the robustness of the model, a series of validation measures were taken. In column (1) of Table 4, the dependent variable was replaced, and the GDP growth rate was used as the new one. Considering that provincial capitals, municipalities directly under the Central Government, and cities separately listed in the state plan may have significant advantages in economic resources and market environment due to their higher administrative level, these advantages may have a strong role in promoting economic growth. Therefore, in column (2) of Table 4, these cities were consciously excluded to reduce the potential interference with the model results.

Table 4. Robustness Test.

Models	(1) LnGDP	(2) LnGDP	(3) LnGDP	(4) LnGDP	(5) LnGDP	(6) LnGDP
IntDID	0.013 ***	0.032 ***	0.0352 ***	0.0255 **	0.0309 ***	0.0240 **
	(2.89)	(3.15)	(3.73)	(2.94)	(3.24)	(2.05)
Constant	−0.234 **	6.340 ***	3.421 ***	5.788 ***	6.017 ***	7.588 ***
	(−2.29)	(6.43)	(3.89)	(4.32)	(6.60)	(6.43)
Controls	Y	Y	Y	Y	Y	Y
Year FE	Yes	Yes	Yes	Y	Y	Y
City FE	Yes	Yes	Yes	Y	Y	Y
N	2827	2488	2810	2827	2827	2260
R^2	0.956	0.953	0.959	0.951	0.953	0.962

Notes: *t*-statistics in parentheses, ** $p < 0.05$, *** $p < 0.01$. Column (1): Replace dependent variables; Column (2): Exclude provincial capitals, municipalities directly under the Central Government, and cities separately listed in the state plan; Column (3): PSM-DID. Column (4) uses clustered standard errors, clustered at the year level; Column (5) applies a 5–95% tail trimming to all continuous variables.

Further, considering the possible non-randomness in the implementation of environmental protection tax collection standards and the high collection standards in areas with mature economic development, this may lead to non-randomness in the experimental and control groups. To correct this potential problem, for column (3) in Table 4, the Propensity score matching–Difference-in-difference (PSM-DID) method was employed to analyze the impact of the environmental "fee to tax" policy on economic growth. Matching variables were determined by Logit regression and matched by a 1:1 nearest neighbor matching method, subsequently removing unmatched cities and performing intensity two-fold differential analysis. Table 4, column (4) uses clustered standard errors, clustered at the year level for estimation. Table 4, column (5) further applies a 5–95% level trimming to all continuous variables. Table 4, column (6) presents the regression results with the sample years shortened by one year before and after.

After examining the robustness regression results in Table 4, it was found in the study that the environmental "fee to tax" policy has a significant positive effect on economic growth, and this effect was verified at the significance level of 1% or 5%. The results of the robustness test remained consistent with the benchmark regression results and also showed small variations in the fluctuations of the coefficients, which further confirms that our empirical results are not only robust but also effective, thus significantly enhancing the credibility and generalizability of the findings.

5.4. Placebo Test

To further ensure the reliability of the dual difference estimation results and avoid being affected by the unobservable potential factors. In this paper, estimated coefficients for a series of spurious policy shocks were generated by randomly reallocating hit individuals and time while maintaining consistency in the overall number of hit samples. Subsequently, the density profiles of these spurious estimated coefficients were plotted to examine their distribution properties. If the distribution of these coefficients is roughly normal, and the mean is very close to zero, the influence of unobservable factors can be considered small,

thus verifying the unbiased and validity of the policy effect estimates in the benchmark regression.

In the specific implementation, 1000 random sampling was carried out, and the relevant results are presented in Figure 2. The results of Figure 2 show that the density distribution map of the false policy shock estimation coefficient basically conforms to the normal distribution, and the mean is very close to zero. This finding suggests that the estimated results in this paper are unlikely to be significantly disturbed by unobservable latent factors, confirming the authenticity and credibility of the estimates. In other words, the policy effects estimated in this paper exist substantially.

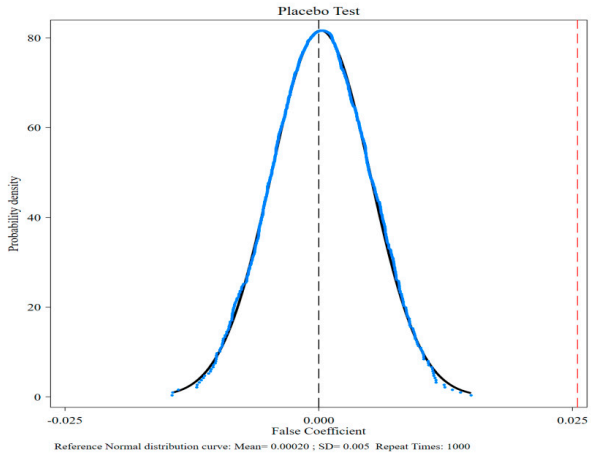

Figure 2. Placebo Test. Notes: The black line represents the fitted normal distribution curve, the blue dots signify the scatter plot of coefficient frequencies within the partitioned intervals, and the red dashed line denotes the actual regression coefficient.

5.5. Testing the Mechanism of Action

Through benchmark regression analysis, we initially observed a positive association between environmental protection taxes and economic growth. To deepen this finding, we further explore whether environmental protection taxes have an impact on economic growth through enhancing investment in science and technology innovation, attracting foreign direct investment, and improving the intensity of tax administration.

(i) Technological innovation

In Model (1) of this study, we employ the number of patent applications in the industrial sector as a proxy for corporate innovation activities and apply natural logarithm transformation to stabilize the variance. Through this analytical approach, we aim to quantify the impact of environmental protection taxes on corporate innovation investment. Our empirical analysis reveals that after the implementation of the environmental tax policy, corporate R&D expenditure has statistically significantly decreased, a result confirmed at the 1% significance level. This finding indicates that environmental protection taxes have not incentivized corporate innovation as theoretically expected; instead, they may have increased operational costs for businesses, crowding out R&D resources and thereby suppressing corporate R&D and innovation activities.

To further elucidate this phenomenon, we introduce a specific case study of a chemical enterprise in Jiangsu Province. Faced with increased environmental compliance costs following the implementation of the environmental tax policy, the enterprise had to reassess and adjust its R&D budget. This led to a reduction in short-term funding for new product development and technological innovation to adapt to stricter environmental standards. Such adjustments not only reduce the enterprise's innovation activities in the short term but may also have adverse effects on its long-term competitiveness.

Our findings are consistent with the research results of Jaffe and Palmer [1], who proposed that stringent environmental regulations may suppress corporate innovation

activities. This study further validates this viewpoint with empirical data and specific case studies, providing a new perspective for understanding the relationship between environmental protection taxes and corporate innovation.

(ii) Foreign Direct Investment

In model (2), we utilize the ratio of FDI to GDP to measure the level of foreign investment. The results show that there is a significant negative correlation between the implementation of environmental protection tax and economic growth. After the implementation of the environmental tax policy in 2018, there is a significant "pollution paradise hypothesis" effect in China; i.e., the environmental protection tax leads to a shift of pollution-intensive industries to regions with less stringent environmental regulations, which is consistent with the research findings of Cole [1].

(iii) Tax collection and administration

Model (3) is constructed to measure the intensity of regional tax regulation:

$$T_{it}/GDP_{it} = \sigma_0 + \beta_1 LnGDP + \beta_2 ind\_1_{it} + \beta_3 ind\_2_{it} + time_t + city_i + \varepsilon_{it} \quad (2)$$

where T_{it} denotes the tax revenue of the ith city in time period t, GDPit denotes the gross domestic product of the ith city in time period t, and ind and ind denote the proportion of added value of the secondary and tertiary industries to GDP, respectively. Through the two-way fixed-effects regression analysis, we use the ratio of the actual tax burden to the estimated tax burden from the model fit to measure the intensity of regional tax administration. The larger the ratio, the higher the intensity of tax administration in the region, and the higher the pressure of tax administration faced by enterprises. The empirical results of model (3) in Table 5 show that the implementation of environmental protection tax significantly increases the regional tax collection intensity. The environmental tax law is significantly higher than the sewage charge in terms of both legal status and intensity of tax collection, and firms are more inclined to adopt advanced and environmentally friendly equipment for production in order to cope with the rise in the cost of the tax burden, which not only pushes emission reduction, but also promotes economic growth. This result is consistent with the study of De Simone and Mazzon [31], who emphasize the role of tax collection intensity in promoting firms' environmental performance. The empirical results of this study suggest that in China, the implementation of an environmental protection tax promotes economic growth mainly through strengthening tax administration. This finding provides a new perspective for understanding the relationship between environmental protection tax and economic growth, and provides an empirical basis for related policy formulation.

Table 5. Results of the Mechanism of Mechanism Test.

Models	(1) Science and Technology Innovation	(2) Foreign Direct Investment	(3) Tax Administration
IntDID	−0.178 ***	−0.001 ***	0.062 *
	(−2.71)	(−4.77)	(1.66)
Constant	8.118 ***	0.004 ***	3.606 ***
	(305.86)	(41.02)	(4.44)
Controls	Y	Y	Y
Year FE	Y	Y	Y
City FE	Y	Y	Y
N	2860	2860	2860
R^2	0.780	0.788	0.724

Notes: *t*-statistics in parentheses, * $p < 0.1$, *** $p < 0.01$.

5.6. Heterogeneity Test

(i) Geographical location heterogeneity

When examining the impact of environmental protection tax reform on economic growth, we recognize that due to differences in geographical location and stages of development, the economic structures and environmental demands of various cities vary significantly, which may lead to heterogeneous effects on the implementation of environmental protection tax policies. Therefore, this paper meticulously divides the research sample into four subsamples: eastern, central, western, and northeastern regions, conducting an in-depth analysis of the socio-economic conditions of each area and discussing how these conditions influence the economic effects of environmental protection tax reform.

Table 6, column (1) shows that in the eastern region, where China's economy is most developed, environmental protection tax is significantly negatively correlated with economic growth. As a region with more developed economies, eastern cities may face pressures to adjust their industrial structures under environmental protection tax reform. The introduction of environmental taxes may prompt these cities to accelerate the transition from traditional manufacturing to services and high-tech industries, although this may have negative impacts on some pollution-intensive industries in the short term. In the long term, environmental taxes may stimulate innovation vitality in the eastern regions, promoting the development of green technology and clean energy industries, thereby positively affecting economic growth.

Table 6. Geographical location heterogeneity.

Models	(1) Eastern	(2) Middle	(3) Western	(4) Northeastern
IntDID	−0.074 ***	0.089 ***	−0.01	0.105 ***
	(−6.55)	(6.35)	(−0.57)	(3.30)
Constant	6.166 ***	7.847 ***	6.448 ***	8.461 ***
	(8.05)	(4.53)	(4.93)	(9.15)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
N	823	800	530	340
R^2	0.973	0.965	0.970	0.915

Notes: *t*-statistics in parentheses, *** $p < 0.01$.

Table 6, column (2) shows that in the central region, environmental protection tax is significantly positively correlated with economic growth. The central region seeks a balance between economic development and environmental protection. Environmental protection tax reform may encourage industrial upgrading in this area, especially in provinces with abundant resources and higher environmental carrying capacities. The incentives of environmental taxes may lead the central region to optimize its economic structure and develop green, low-carbon industries, achieving a win-win situation for environmental protection and economic growth.

Table 6, column (3) shows that in the western region, there is no significant correlation between environmental protection tax and economic growth. The western region, relatively lagging in economic development, may see environmental protection tax reform as a new opportunity for industrial structure adjustment and green economic development. Although the impact of environmental taxes may not be immediately apparent in the short term, in the long term, with appropriate policy support and market cultivation, the Western region is expected to optimize its economic structure and upgrade its industries through environmental protection tax reform.

Table 6, column (4) indicates that in the northeastern region, where the economy is relatively underdeveloped, there is a strong significant positive correlation between environmental protection tax and economic growth. As a traditional base for heavy indus-

try, the northeast region may have experienced the transformation and upgrading of its industrial structure under environmental protection tax reform. The implementation of environmental taxes may have facilitated the renovation of high-pollution, high-energy-consuming industries and the development of emerging industries, positively affecting economic growth.

Through an in-depth analysis of the socio-economic conditions of various regions, this paper reveals the heterogeneous impact of environmental protection tax reform on the economic development of cities in different regions. These findings provide policymakers with a targeted decision-making basis, helping to further optimize environmental protection tax policies and achieve sustainable development of regional economies. By refining regional analysis, this paper not only explains the observed heterogeneity in tax effects but also provides an empirical basis for formulating differentiated environmental policies.

(ii) Administrative level heterogeneity

The different administrative levels of cities may lead to differences in management intensity and other aspects, which could cause the impact of environmental protection taxes on economic growth to exhibit heterogeneity. Although we have verified the robustness of our research conclusions by excluding samples of municipalities directly under the Central Government in the robustness test, the changes in the coefficient values are still worth paying attention to. Therefore, this study divides the total sample into two subsamples, high-administrative-level cities and low-administrative-level cities, based on whether the cities are above the vice-provincial level, and conducts subsample regression analysis. The results are shown in columns (1) and (2) of Table 7

Table 7. Administrative level heterogeneity.

Models	**(1)** **LnGDP**	**(2)** **LnGDP**
IntDID	0.0266 **	−0.154 ***
	(2.39)	(−3.73)
Constant	5.610 ***	17.59 ***
	(4.93)	(10.87)
Controls	Y	Y
Year FE	Y	Y
City FE	Y	Y
N	2737	90
Adjust.R^2	0.949	0.930
F	25.530	3.939

Notes: *t*-statistics in parentheses, ** $p < 0.05$, *** $p < 0.01$; Column (1) represents non-central cities, and Column (2) represents central cities.

The analysis reveals an interesting phenomenon: environmental protection taxes have a positive effect on enhancing the economic resilience of low-administrative-level cities, while they have a significant inhibitory effect on the economic growth of high-administrative-level cities. This difference may stem from various factors. For low-administrative-level cities, environmental protection taxes may serve as an incentive mechanism, encouraging these cities to pay more attention to the balance between environmental protection and economic development, thereby improving their economic adaptability and resilience. For high-administrative-level cities, due to their more complex economic structures, the implementation of environmental protection taxes may increase the operational costs for businesses, thus having a negative impact on economic growth. These findings emphasize the need to consider the characteristics and needs of cities with different administrative levels when formulating and implementing environmental protection tax policies, in order to achieve a win-win situation for both environmental protection and economic growth.

5.7. Extensibility Analysis

This paper further explores the impact of environmental protection tax on pollutant discharge in order to evaluate its effect on pollution control. Specifically, Table 8 details the impact of Etax on the per capita industrial sulfur dioxide, industrial wastewater per capita, and industrial dust emissions per capita. The results showed that the environmental protection tax statistically significantly reduced the emissions of industrial sulfur dioxide and industrial dust per capita. However, the impact of the environmental protection tax was not statistically significant for industrial wastewater discharge levels per capita.

Table 8. Extensibility Analysis.

Models	(1) Industrial Sulfur Dioxide	(2) Industrial Waste Water	(3) Industrial Dust
IntDID	−0.150 ***	0.016	0.140 *
	(−2.39)	(1.18)	(−1.77)
Constant	0.009 ***	0.001 ***	0.007 ***
	(29.73)	(25.38)	(23.98)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
N	2900	2900	2900
R^2	0.685	0.437	0.660

Notes: (1) *t*-statistics in parentheses, * $p < 0.1$, *** $p < 0.01$.

Combining these findings, it can be concluded that the environmental protection tax not only plays a positive role in promoting economic development, but also shows its environmental benefits in reducing the emission of some pollutants. This phenomenon reflects the "double dividend" effect of environmental protection tax, that is, while promoting economic growth, it effectively reduces environmental pollution and realizes the coordinated development of the economy and environment. This shows that by formulating reasonable environmental protection tax policies, we can achieve environmental protection while promoting economic prosperity.

6. Conclusions and Recommendations

Taking the "fee to tax" policy implemented in China in 2018 as an opportunity for a natural experiment, this study empirically analyzes the impact of environmental protection tax reform on regional economic growth by using a strengthened double-difference (DID) model. It is found that environmental protection tax reform has a significant positive impact on regional economic growth, and this conclusion is still robust after several robustness tests. To explore the mechanism of environmental protection tax in-depth, this study analyzes the three dimensions of scientific and technological innovation, foreign direct investment, and tax administration intensity. The results show that environmental protection tax does not promote technological innovation of enterprises as expected, but may instead inhibit R&D and innovation activities by increasing the cost pressure on enterprises. The positive effect of environmental protection tax on economic growth is mainly realized by increasing the intensity of tax administration. Additionally, this study analyzes the heterogeneity in urban geographic locations and administrative levels, and finds that environmental protection taxes have a more significant positive impact on economic growth in central and northeastern regions and in cities with lower administrative levels, while a negative effect is observed in the eastern region and in cities with higher administrative levels. The aforementioned conclusions offer a fresh perspective for understanding the relationship between environmental protection taxes and economic growth. By revealing how environmental protection taxes promote economic growth through their impact on tax administration intensity, this study enriches the theory of environmental economics and provides new directions for subsequent research. Furthermore, this study also explores the effects of

environmental protection taxes on corporate innovation behavior, providing theoretical support for understanding how environmental policies influence corporate actions. Based on the above findings, this paper puts forward the following policy recommendations:

First, it is suggested that the government should fully consider the economic development level, industrial structure, and environmental carrying capacity of different regions when formulating environmental protection tax policies. Implementing differentiated tax rates can ensure that the environmental protection tax can effectively incentivize enterprises to reduce pollution emissions without causing excessive pressure on the economic development of the region. For more economically developed and environmentally sensitive regions, the tax rate can be appropriately increased to strengthen the incentive to reduce emissions; while for economically relatively backward regions, consideration should be given to lowering the tax rate to reduce the tax burden on enterprises. Second, in order to ensure the effective implementation of the environmental protection tax policy, it is recommended that the tax authorities strengthen the supervision and enforcement of the environmental protection tax. Through regular audits and supervision, they should ensure that enterprises pay taxes in compliance and reduce tax evasion. At the same time, the transparency and fairness of tax collection and management should be improved to enhance the trust of enterprises in the tax policy, so as to improve the implementation of the tax policy. Third, to encourage enterprises to reduce pollution emissions through technological innovation, the government should provide tax incentives or relief measures, especially in the field of environmental protection technology. Setting up incentives such as special tax breaks and R&D subsidies can stimulate the enthusiasm of enterprises for R&D and promote the development and application of more environmentally friendly and efficient production technologies. This will not only help enterprises reduce their tax burden but also improve their market competitiveness. Fourth, it is recommended that the government establish a long-term tracking and assessment mechanism for the environmental protection tax policy to regularly monitor and assess the effectiveness of the policy's implementation. Collecting and analyzing data can assess the actual impact of environmental protection tax on industrial pollution reduction and output growth. Based on the assessment results, the tax policy should be adjusted in a timely manner to ensure the adaptability and effectiveness of the policy in response to new trends in economic development and environmental protection.

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