RESEARCH ARTICLE

OPEN ACCESS

https://doi.org/10.17059/ekon.reg.2024-4-22
UDC: 336.025
JEL: C520, H230

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The Impact of China's Environmental Protection Tax on Regional Economic Effects[1]

Abstract. In 2018, China adopted the Environmental Protection Tax Law, transitioning from administrative fees to statutory taxes. The law aimed to incentivize enterprises to reduce pollution emissions through economic means, improve environmental quality, and promote the optimization and upgrading of industrial structures for economic development. This study seeks to reveal the mechanisms of the impact of environmental protection tax on regional economic effects, providing policy recommendations for achieving high-quality economic development and ecological environmental protection. The study analyses four key variables—environmental protection tax revenue, regional industrial output value, regional GDP, and regional industrial pollution control investment—from 31 regions in China between 2018 and 2022, forming a sample of 30 observations. A random effects model is constructed and empirically analysed using Python 3.12. The empirical results show that for every additional unit of environmental protection tax, the average expected growth of regional GDP is 0.1043 units. There are significant differences in the economic effects of China's environmental protection tax on regions, and these differences have random effects. This study provides new insights and empirical evidence for understanding and evaluating the impact of environmental protection taxes on regional economic outcomes, helping policymakers assess current impacts and continue encouraging enterprises to adopt clean production technologies, improve energy efficiency, and promote economic structure optimization and industrial upgrading to support high-quality economic development.

Keywords: Regions of China, Environmental Protection Tax, Regional Economic Effects, Random Effects Model, Environmental Tax Policy

For citation: Chenghao, Y., Mayburov, I.A., & Ying, W. (2024). The Impact of China's Environmental Protection Tax on Regional Economic Effects. *Ekonomika regiona / Economy of Regions, 20(4)*, 1315-1326. https://doi.org/10.17059/ekon.reg.2024-4-22

ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

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Влияние налога на охрану окружающей среды в Китае на региональные экономические эффекты

Аннотация. В 2018 г. в Китае был официально принят закон о налоге на охрану окружающей среды, ознаменовавший переход от административных сборов к экологическим налогам. Закон направлен на стимулирование предприятий к сокращению выбросов загрязняющих веществ налоговыми средствами, улучшению качества окружающей среды и одновременному содействию оптимизации и модернизации промышленных структур для экономического развития. Целью данного исследования является выявление механизмов влияния налога на охрану окружающей среды на региональные экономические эффекты, выработка рекомендаций для достижения качественного экономического развития и охраны окружающей среды. В качестве четырех ключевых переменных для формирования 30 выборок наблюдений взяты налоговые поступления от налогов на охрану окружающей среды, региональный объем промышленного производства, региональный ВВП и региональные инвестиции в борьбу с промышленным загрязнением из 31 региона Китая в период с 2018 по 2022 гг. Модель случайных эффектов построена и эмпирически проанализирована с помощью Python 3.12. Эмпирические результаты показывают, что для каждой дополнительной единицы налога на охрану окружающей среды средний ожидаемый рост регионального ВВП составляет 0,1043 единицы. Показаны значительные различия в экономическом влиянии налога на охрану окружающей среды Китая на регионы, и эти различия имеют случайные эффекты. Эти результаты дают новую перспективу и эмпирические данные для понимания влияния налога на охрану окружающей среды на региональные экономические эффекты, помогая органам власти оценивать текущие эффекты этого налога, постоянно мотивировать предприятия к внедрению экологически чистых производственных технологий и повышению энергоэффективности, способствовать оптимизации экономической структуры и модернизации промышленности, а, следовательно, и высококачественному экономическому развитию.

Ключевые слова: регионы Китая, налог на охрану окружающей среды, региональные экономические эффекты, модель случайных эффектов, экологическая налоговая политика

Для цитирования: Чэнхао, Е., Майбуров, И.А., Ин, В. (2024). Влияние налога на охрану окружающей среды в Китае на региональные экономические эффекты. *Экономика региона, 20(4)*,1315-1326. https://doi.org/10.17059/ekon.reg.2024-4-22

Introduction

Amid global climate change and worsening environmental conditions, achieving sustainable development has become a global priority. As the world's largest developing country, China has experienced rapid economic growth in recent years, but this progress has come at significant environmental costs.

From 2018 to 2022, China's economic losses from environmental issues steadily increased, rising from RMB 550 billion (US$81 billion) in 2018 to RMB 750 billion (US$109 billion) in 2022.[1] These losses include impacts from natural disasters, air pollution, and long-term ecological damage.

According to China's Ministry of Ecology and Environment[2], the country's average concentration of PM2.5—fine particulate matter measuring 2.5 micrometers or smaller[3]—was 39 micrograms per cubic meter in 2018 and 29 micrograms per cubic meter in 2022. Both levels significantly exceed the World Health Organization's 2018 recommended annual standard of 10 micrograms per cubic meter. In addition, China's water shortage and water pollution problems are equally severe. About 80 % of the annual average available water resources are concentrated in the eastern and southern regions of China, while the water resources in the western and northern regions are relatively small. The annual comprehensive utilization rate of water resources is only 43 %, while the utilization rate of developed countries is above 80 % on average.[4]

[1] https://www.mee.gov.cn/hjzl/sthjzk/sthjtjnb/ (Ministry of Ecology and Environment the People's Republic of China, Date of access: 01.03.2024)

[2] https://www.mee.gov.cn/xxgk2018/xxgk/xxgk15/201903/t20190318_696301_wh.html (Ministry of Ecology and Environment the People's Republic of China, Date of access: 01.03.2024)

[3] PM2.5 particles are a major air pollutant, known to penetrate deep into the lungs and cause serious health issues.

[4] https://dialogue.earth/zh/3/43937/ (China is heading towards a water crisis: will government changes help?, Date of access: 01.03.2024)

The data above point to the urgent need to strengthen environmental protection policies to mitigate the economic impact of environmental problems. By implementing effective environmental tax policies, enhancing governance, and promoting green economic development, China can reduce future economic losses and achieve more sustainable growth. As societal demands for improved environmental quality continue to rise, environmental protection has become a key national strategy.

In 2018, China officially implemented the Environmental Protection Tax Law 1, a significant reform in China's environmental governance seeks to leverage policy mechanisms to reduce pollution, conserve resources, and promote green, low-carbon development. Studying the impact of the environmental protection tax on regional economic outcomes holds substantial significance for implementing the policy effectively and also provides a fresh perspective on the relationship between tax policy and environmental protection.

Although the environmental protection tax has been in place for some time, its impact on the regional economy and effectiveness remains a focal point of public and academic interest. Ongoing research primarily focuses on the macroeconomic effects of the environmental protection tax and the broader analysis of pollution (Ren et al., 2024), with less attention given to regional differences and their underlying causes. Given China's vast territory and the significant variations in economic development, industrial structures, and environmental burdens across regions, these factors contribute to the heterogeneous impact of the environmental protection tax on regional economic growth.

We have previously (Chenghao et al., 2024) proved that for every 1 percentage point increase in the growth rate of total tax revenue, the growth rate of China's environmental tax revenue increases by about 0.8489 percentage points, with an average growth rate of environmental tax revenue of about 0.9797 percentage points. This provides China with a benchmark to achieve the goal of high-quality economic growth in terms of continuous reform and development of environmental taxes.

It should be noted that the impact of the environmental protection tax on economic growth is complex and varied. On the one hand, the environmental protection tax can stimulate enterprises to adopt clean production technologies and improve production efficiency by increasing the cost of pollution, thereby having a positive impact on economic growth; on the other hand, the collection of environmental protection tax may also increase enterprise costs, suppress economic activities, and have a negative impact on economic growth. Considering the differences in economic development levels and environmental conditions among regions, exploring the effects of environmental protection tax in different regions is of great significance for formulating region-specific environmental policies.

In view of this, this study poses the following research questions:

1. What impact does the environmental protection tax have on the economic effects of various regions in China?
2. Are there significant variations in the economic effects of the environmental protection tax across regions?
3. Do these differences have random characteristics?

Based on these research questions, we have formulated the following hypotheses:

H1: The environmental protection tax has a positive impact on economic growth in various regions of China.

H2: There are significant differences in the economic effects of the environmental protection tax across regions, and these differences have random characteristics.

This study aims to shed light on the mechanisms through which the environmental protection tax impacts regional economic outcomes, offering policy recommendations for achieving high-quality economic development and ecological protection.

Literature Review

To study the impact of the environmental protection tax on regional economic outcomes, it is essential to start with environmental economics, including Pigou's (1920) theory of externalities. Pollution, as a negative externality, imposes costs on society that are not borne by producers. The environmental protection tax internalizes these external costs, requiring polluters to pay for the social damages, thus incentivizing companies to reduce emissions. Due to regional differences in industrial structure, technological development, and environmental governance capabilities, the effectiveness of the environmental protection tax will vary, reflecting random effects.

[1] https://www.mee.gov.cn/ywgz/fgbz/fl/201811/t20181114_673632.shtml (Ministry of Ecology and Environment of the People's Republic of China, Environmental Protection Tax Law of the People's Republic of China, Date of access: 01.03.2024)

The theoretical foundation for the study of the effects of environmental policies in different regions was laid by the following theories.

First, Isard's (1956) theory of spatial differences in regional economics highlights the variations in resource endowments, economic development, and industrial structures across regions. This regional heterogeneity aligns with the random effects model, which assumes that each region has unique, unobservable characteristics. Treating these characteristics as random variables helps capture regional differences, such as economic foundations and policy environments, providing a more accurate reflection of the environmental protection tax's impact and enabling better estimation of regional policy effects.

Second, Krugman's (1992) theory of regional heterogeneity argues that regional differences in economic structure, resource endowments, and government environmental awareness lead to varying impacts of environmental protection taxes. This theory aligns with the random effects model and supports the study of environmental protection tax impacts across China's regions.

Grossman and Krueger's (1995) environmental Kuznets curve theory suggests that regions will respond differently to environmental taxes at different stages of economic development. Developed regions, having entered the environmental improvement phase, are more responsive to environmental taxes, while underdeveloped regions, still in the rising pollution phase, show weaker effects. Thus, using random effect models in panel data analysis can capture this regional heterogeneity.

North's (1990) institutional theory highlights regional differences in policy enforcement, regulatory completeness, and government efficacy, which influence the economic effects of environmental tax policies. Even within the same country, variations in the intensity and effectiveness of environmental protection policies across regions can impact the actual outcomes of environmental protection taxes.

Finally, Holland's (2006) theory on the interaction of economic, social, and environmental factors suggests that these factors may lead to regional variations in the effects of environmental protection taxes, introducing randomness into the outcomes across different areas.

Subsequent studies have examined the economic effects of environmental taxes at national, regional, and international levels. For instance, Liu et al. (2022) found that the implementation of environmental taxes led to a significant increase in corporate environmental investment, which, in turn, improved corporate performance. Drawing on this paper's findings, we have decided to incorporate in our study environmental governance investment as a key factor.

Li et al. (2021) used a CGE model to assess China's environmental tax policy, finding that while environmental policies negatively affect GDP, the impact is small. They predict that higher environmental and carbon taxes by 2030 will lead to a greater GDP loss, emphasizing the economic trade-offs. Wang et al. (2019) demonstrated that converting pollution discharge fees into environmental taxes increased environmental productivity in all regions of China, though the economic impact varied regionally due to the trade-off between environmental protection and economic growth. In contrast, Liu & Ge (2023) used the CEG model and found that increasing environmental tax rates in optimal scenarios reduced pollutants and boosted GDP, suggesting a moderate tax increase would benefit most regions. Fan et al. (2021) developed a framework showing that combining environmental taxes with pollution control subsidies can enhance corporate incentives, creating a virtuous cycle of economic growth and environmental protection. Sun et al. (2023) argue that developing countries can learn from China's experience in balancing environmental challenges with economic sustainability. Rakpho et al. (2023) suggest that environmental tax mechanisms can incentivize economic sectors, though G7 countries experienced negative effects from high carbon tax rates. These studies share a common focus on examining the economic impacts of environmental tax policies, exploring how such policies influence productivity, economic growth, and environmental outcomes across different regions and sectors.

A separate group of studies examine the economic impact of environmental taxes. For example, Kumbhakar et al. (2022) found that, when using a by-production model within a stochastic frontier framework, adjusting production processes to improve efficiency favored economic efficiency over environmental efficiency. Abdullah & Morley (2014) used panel cointegration and error correction techniques to demonstrate that economic growth drives environmental taxes, with little causal relationship between taxes and growth. Additionally, they found that short-term environmental subsidies negatively impacted growth. Aloi & Tournemaine (2011) showed that stricter environmental taxes positively affected growth, productivity, and green innovation research, yielding long-term welfare benefits, and possibly some short-term gains. Patuelli et al. (2005) conducted a comprehensive analysis revealing that environmental tax and recycling policies significantly impacted economic variables, particularly employment, while the effect on GDP was less pronounced.

Several studies explore the positive economic impacts of environmental improvements, particularly through the double dividend hypothesis. Glomm et al. (2008) used a dynamic general equilibrium model to find that increasing gasoline taxes while reducing capital income taxes could yield both efficiency and environmental benefits. Ciaschini et al. (2012) argued that appropriate environmental taxation stimulates economic growth alongside environmental protection, creating a win-win scenario. Hart (2004) showed that environmental taxes could drive increased production growth, while Bovenberg & De Mooij (1997) examined the effects of environmental tax reform on pollution, economic growth, and welfare. Hassan et al. (2020) highlighted differences in the impact of environmental tax reform (ETR) between countries with and without such policies, while Brock & Taylor (2005) linked taxation to economic development through the environmental Kuznets curve.

Other analyses, however, have drawn different conclusions. Hu et al. (2021) found that carbon taxes had a better economic effect than resource taxes. Bosquet (2000) suggested that environmental tax reform could lead to short – or medium-term economic gains or losses with uncertain long-term effects. Wesseh & Lin (2019) argued that a unified carbon tax policy could achieve a double dividend, while partial policies would not. Durusu-Ciftci et al. (2018) found that only consumption taxes significantly affected GDP, with varying effects across OECD countries. Vellinga (1999) claimed that environmental protection may influence short-term growth but not long-term growth rates. Oueslati (2014) noted that the impact of environmental tax reform on growth depends on tax reform type and investment adjustment costs, with short-term welfare effects being negative. Xie et al. (2023) found that environmental taxes hurt corporate investment efficiency, while Zhang et al. (2024) noted that small-scale macro tax burdens incentivized growth, but large ones had the opposite effect. Finally, Hu et al. (2023) and Renstrцm et al. (2021) examined regional changes in emissions and GDP due to carbon tax implementation, with Renstrцm et al. suggesting that higher pollution taxes reduce consumption and economic scale but increase subsidies for emission reduction. These studies highlight the varying economic effects of environmental taxes across regions and over time.

Barnea et al. (2005) believe that green investors can prompt polluting companies to reform, while socially responsible investment leads to underinvestment by polluting companies, resulting in a decline in overall economic investment.

The literature review can be summarized in three key points:

1) Economic effects of the environmental protection tax: The academic literature examines both theoretical and empirical aspects of the impact of such taxes on economic growth, with a particular focus on how these taxes influence industrial structure optimization, technological innovation, and resource allocation efficiency.

2) Regional differences: Studies in this area explore the varying implementation effects of environmental policies across different regions or countries, highlighting the reasons behind these differences and the resulting impact of environmental protection taxes on economic growth in diverse regions.

3) Relationship between environment and economic growth: This body of research investigates the dynamic relationship between environmental protection and economic growth, in particular how environmental protection policies affect economic growth through channels such as corporate costs, consumer behaviour, and international trade.

Methods and Data

3.1. Methods

This study employs quantitative analysis methods, including cross-sectional and time series data, along with panel data analysis techniques. The specific steps are as follows:

1) Collect economic data from various regions in China;

2) Construct econometric models to assess the impact of environmental protection taxes on regional economic outcomes;

3) Use random effects or fixed effects models for parameter estimation, testing the economic effects and characteristics of the environmental protection tax.

The data primarily come from the National Bureau of Statistics of China, regional statistical yearbooks, regional official websites, and official data released by environmental protection departments. The study focuses on data related to environmental protection tax revenue, regional industrial output, regional GDP, and industrial pollution control investment, collected from 31 regions across China's northern, north-eastern, eastern, south-eastern, central, and western areas. The analysis is conducted using a random effects model in Python.

3.2. Sample Selection

The data encompasses 23 provinces, 5 autonomous regions, and 4 municipalities in China from 2018 to 2022. Based on the classification criteria of the National Bureau of Statistics of China, these 31 areas are divided into 6 regions. These regions are geographically adjacent, with similar economic structures and industrial levels, which aligns with the focus of this study.

Four key variables were selected for our analysis: regional environmental protection tax revenue, regional industrial output value, regional GDP, and industrial pollution control investment, forming 30 observation samples. All numerical data are log-transformed for analysis. Figure 1 illustrates the areas included in the six regions that make up our study sample.

Table 1 presents a division based on comprehensive statistical, research, and tax foundation criteria. Specifically, the Northern region centres around the capital and includes five adjacent areas with similar economic structures; the North-eastern region comprises three adjacent areas, forming China's heavy industrial base with similar regional economic structures; the Eastern region centres around Shanghai and includes eight coastal areas; the South-eastern region is centred around Guangzhou and consists of six adjacent areas; the Central region is centred around Chongqing with five neighbouring areas; and the Western region centres around Ningxia, including five adjacent areas. All variables are natural log-transformed, and the descriptive statistics of the data are provided in Table 2.

Results

4.1. Relationship Analysis

Initially, we conducted a linear regression analysis, using regional Gross Domestic Product as the dependent variable to explore the linear relationships among various variables. The results are presented in Tables 3 and 4.

The constant term is 0.6771, which suggests that when all independent variables are 0, the baseline

Fig. 1. *Map of China's 6 regional divisions*

Source: Map of the People's Republic of China. https://www.gov.cn/guoqing/2017-07/28/content_5043915.htm (Date of access:01.03.2024)

Table 1

Names and Abbreviations of the Variables

Variable	Regional GDP	Environmental Protection Tax	Industrial Output Value	Industrial Pollution Control Investment
Abbreviation	R-GDP	EPT	IOV	IPCI
Types of Variables	Explanatory variable Y	Explained variable X1	Explained variable X2	Explained variable X3

Source: compiled by the authors

Table 2

Data Description

Variable	Maximum	Minimum	Mean	Median	Variance
Regional GDP	5.665	4.701	5.124	5.080	0.109
Environmental Protection Tax	5.856	4.877	5.414	5.407	0.102
Industrial Output Value	5.210	4.164	4.616	4.523	0.123
Industrial Pollution Control Investment	6.456	4.994	5.749	5.743	0.129

Source: authors' calculations

Table 3

OLS Regression Results

Parameter	Meaning	Parameter	Meaning
Dep. Variable	R-GDP	R-squared	0.990
Model	OLS	Adj. R-squared	0.989
Method	Least Squares	F-statistic	864.4
No. Observations	30	Prob (F-statistic)	3.78e-26
Df Residuals	26	Log-Likelihood	60.434
Df Model	3	AIC	-112.9
Covariance Type	nonrobust	BIC	-107.3
Omnibus	0.153	Durbin-Watson	2.006
Prob(Omnibus)	0.927	Jarque-Bera (JB)	0.028
Skew	0.054	Prob(JB)	0.986
Kurtosis	2.894	Cond. No.	171.

Source: data were obtained from the authors' calculations using Python 3.12.

Table 4

Linear Regression Analysis Options

Parameter	Coef.	std err	t	P>|t|	Interval [	]
const	0.6771	0.116	5.848	0.000	0.439	0.915
EPT	0.0827	0.033	2.475	0.020	0.014	0.151
IOV	0.8923	0.032	27.751	0.000	0.826	0.958
IPCI	-0.0208	0.030	-0.704	0.488	-0.082	0.040

Notes: Standard Errors assume that the covariance matrix of the errors is correctly specified
Source: data were obtained from the authors' calculations using Python 3.12.

value of *R-GDP* is approximately 0.6771, and this result is highly significant (p-value = 0.000). The model results indicate that environmental protection taxes and industrial output have a significant positive effect on R-GDP, whereas industrial pollution control investment has a negative impact, although it is not statistically significant. This provides a foundation for further empirical analysis using time series and panel data.

4.2. Model Selection

Initially, our hypotheses and theoretical framework led us to select the random effects model for analysis. However, to ensure robustness and accuracy, we also compared it with the fixed effects model and conducted a Hausman test, with the results presented in Table 5.

This model comparison provides results from both the fixed effects model and the random effects model, assessing the impact of these two different methods on *R-GDP*. The *R*-squared and *F*-statistic indicate that the explanatory variables in the random effects model have a stronger statistical significance overall on the dependent variable. The impact of EPT is slightly stronger in the random effects model than in the fixed effects model, and the positive impact of IOV on R-GDP is more significant in the random effects model, with *IPCI* showing a slight positive effect in the random effects model.

In light of the above results, although the numerical outcomes of the Hausman test are not provided, other indicators show that the random effects model offers stronger and more significant explanatory power for *R-GDP*, providing sufficient evidence to support its use.

4.3. Random Effects Model Analysis Results

The random effects model equation is constructed to describe the relationship between R-GDP and EPT, IOV, and IPCI:

$$R - GDP_i = \beta_0 + \beta_1 \cdot EPT_i + \beta_2 \cdot IOV_i + \\ +\beta_3 \cdot IPCI_i + \mu_i + \varepsilon_i, \qquad (1)$$

where R-GDPi is the *GDP* of region *i*; β0 is the intercept term; EPTi is the environmental protection tax of region *i*; IOV_i is the industrial output value of region *i*; $IPCI_i$ is the industrial pollution control investment of region *i*; β1, β2, β3 are model parameters, measuring the impact of environmental protection taxes, regional industrial output value, and industrial pollution control investment on regional *GDP*, respectively; μi is the random effects term, capturing region-specific effects that do not change over time; εi is the error term, representing the impact of other unobserved factors.

Random effects regression analysis was conducted (see the results in Tables 6 and 7).

These random effects model analysis examines the impact of four explanatory variables, namely environmental protection tax, industrial output value, and industrial pollution control investment, on the regional *GDP* of the explained variable. The model shows no significant multicollinearity or heteroscedasticity issues. *R*-squared values indicate strong explanatory power across regions. The constant term (0.6232) represents the expected regional *GDP* when all variables are zero, with statistical significance ($P < 0.01$).

For the environmental protection tax, the coefficient of 0.1043 means that for each additional unit of tax, regional *GDP* is expected to grow by 0.1043 units, statistically significant at the 5 % level ($P = 0.0220$).

Industrial output value has a substantial impact, with a coefficient of 0.8282, meaning that each unit increase in output leads to a 0.8282 unit

Table 5

Model Comparison (Hausman_test)

Parameter	Fixed Effects	Random Effects
Dep. Variable	R-GDP	R-GDP
Estimator	PanelOLS	RandomEffects
No. Observations	30	30
Cov. Est.	Unadjusted	Unadjusted
R-squared	0.8747	0.9682
R-Squared (Within)	0.8747	0.8622
R-Squared (Between)	0.9652	0.9908
R-Squared (Overall)	0.9635	0.9885
F-statistic	48.884	264.07
P-value (F-stat.)	0.0000	0.0000
Const.	1.2379 (2.1493)	0.6232 (3.1397)
EPT	0.1248 (2.3366)	0.1043 (2.4362)
IOV	0.6990 (7.8043)	0.8282 (19.448)
IPCV	-0.0028 (-0.0974)	0.0197 (0.9852)

Notes: T-stats reported in parentheses
Source: data were obtained from the authors' calculations using Python 3.12.

Table 6

Random Effects Estimation

Parameter	Meaning	Parameter	Meaning
Dep. Variable	R-GDP	R-squared	0.9682
Estimator	RandomEffects	R-squared (Between)	0.9908
No. Observations	30	R-squared (Within)	0.8622
Cov. Estimator	Unadjusted	R-squared (Overall)	0.9885
Entities	6	Log-likelihood	76.705
Avg Obs.	5.0000	F-statistic	264.07
Min Obs.	5.0000	P-value	0.0000
Max Obs.	5.0000	Distribution	F(3,26)
Time periods	5	Min Obs.	6.0000
Avg Obs.	6.0000	Max Obs.	6.0000

Source: data were obtained from the authors' calculations using Python 3.12.

Table 7

Parameter Estimates

Parameter	Meaning	Std. Err.	T-stat.	P-value	Lower CI	Upper CI
Const.	0.6232	0.1985	3.1397	0.0042	0.2152	1.0312
EPT	0.1043	0.0428	2.4362	0.0220	0.0163	0.1922
IOV	0.8282	0.0426	19.448	0.0000	0.7407	0.9157
IPCI	0.0197	0.0200	0.9852	0.3336	-0.0214	0.0609

Source: data were obtained from the authors' calculations using Python 3.12.

increase in regional *GDP* (*P* = 0.0000). This highlights the strong role of industrial output in driving economic growth.

Industrial pollution control investment, however, does not show a statistically significant effect on regional *GDP*, suggesting that its contribution to economic growth may be limited or not immediately evident.

Discussion

The results of our empirical analysis demonstrate that environmental protection taxes have a significant positive impact on economic growth across various regions of China, with notable regional differences characterized by random effects. This supports the "Porter Hypothesis" in environmental economics, suggesting that well-designed environmental regulations can stimulate innovation, enhance resource efficiency, and foster economic growth. Additionally, industrial output value significantly influences regional GDP, highlighting its critical role in economic development. However, the impact of industrial pollution control investment on regional GDP is not significant, possibly due to the delayed economic returns of such investments or limitations in the available data.

Hypothesis H1 is confirmed. The empirical results show that the coefficient of the explanatory variable environmental protection tax is 0.1043, which means that for every additional unit of environmental protection tax, the average expected growth of regional *GDP* is 0.1043 units, which is statistically significant at the 5 % level, verifying the hypothesis that the environmental protection tax has a positive impact on economic growth in various regions of China.

Hypothesis H2 is confirmed. The empirical results show that the constant term (const): 0.6232, represents the estimated value of regional *GDP* when all explanatory variables are zero. The significance of the constant term (*P* value <0.01) indicates that the intercept of the model is statistically significant. It is verified that there are significant differences in the economic effects of China's environmental protection tax on regions, and these differences have random effects.

This study has some limitations. Due to data constraints, it could not examine the specific impact of environmental protection taxes on regional environmental quality. Future research could explore the dual benefits of environmental tax policies on both the economy and the environment. Additionally, this study uses regional-level macro data, without addressing micro-level mechanisms at the enterprise level. Future studies could integrate micro-data to further understand the effects of environmental protection tax policies.

In conclusion, this empirical analysis of the relationship between the environmental protection tax and economic growth across six regions in China confirms the positive role of environmental protection taxes in promoting regional economic growth. The findings offer valuable insights for the development of environmental policies and provide new avenues for future research in this area.

Conclusion and Policy Recommendations

Our study confirmed both hypotheses. The coefficient of 0.1043 means that for every additional unit of environmental protection tax, the average expected growth of regional GDP is 0.1043 units, which is statistically significant at the 5 % level. It is verified that there are significant differences in the economic effects of China's environmental protection tax on regions, and these differences have random effects.

The findings of this study have significant implications for policymakers. The positive economic effects of the environmental protection tax suggest that well-designed environmental policies can foster economic development. Based on these conclusions, the following policy recommendations are proposed:

Firstly, optimize environmental protection tax policy to promote green growth. Based on the positive correlation between the environmental protection tax and regional *GDP* (as shown in hypothesis H1), it is recommended that the government further refines the tax policy. The impact, as shown by the random effects model, is modest, particularly when compared to the impact of industrial output. Therefore, it is crucial to ensure that the tax system effectively encourages enterprises to adopt environmental technologies and management practices.

Secondly, enhance industrial output value quality and support structural upgrading. The study shows that each unit increase in industrial output value corresponds to an average 0.8282 unit increase in regional *GDP*. Given the importance of industrial output in regional growth, it is recommended to boost support for advanced manufacturing and high-tech industries, guiding investments toward sectors with high output and low pollution. Policies should encourage the transformation of traditional manufacturing to intelligent manufacturing, enhancing technological content and optimizing industrial structure.

Thirdly, increase support for industrial pollution control and improve incentive mechanisms. While industrial pollution control investment does not have a significant direct impact on regional GDP, it is essential for improving environmental quality and residents' well-being. It is recommended that the government provide more support to pollution control efforts through financial subsidies, tax incentives, and other measures, particularly for small and medium-sized enterprises. Additionally, establishing and strengthening environmental reward and penalty systems can motivate companies to enhance their environmental performance.

In summary, this study empirically demonstrates that the environmental protection tax positively impacts regional economic growth, with varying effects across different regions. It means that the tax can drive economic development in a more sustainable direction, while highlighting the role of regional differences in the effectiveness of environmental policies. Additionally, industrial output value emerges as a key driver of regional *GDP* growth, and the positive impact of the environmental protection tax on GDP indicates that environmental policies and economic development can complement rather than conflict with each other.

On the theoretical level, our findings agree with the concepts presented in externality theory, Coase's theorem, regional economics, regional heterogeneity, the environmental Kuznets curve, institutional theory, and corporate behavior and innovation theory, enriching their relevance in the Chinese context. Practically, the study highlights the importance of considering the economic characteristics, development levels, and institutional environments of different regions when formulating and implementing environmental protection tax policies.

Policymakers should use flexible tools to promote technological innovation and industrial upgrading while strengthening institutional frameworks to enhance policy effectiveness. By doing so, the environmental protection tax can drive regional economic transformation and contribute to high-quality development in China's economy.

References

Abdullah, S., & Morley, B. (2014). Environmental taxes and economic growth: Evidence from panel causality tests. *Energy Economics, 42,* 27–33. https://doi.org/10.1016/j.eneco.2013.11.013

Aloi, M., & Tournemaine, F. (2011). Growth effects of environmental policy when pollution affects health. *Economic Modelling, 28*(4), 1683–1695. https://doi.org/10.1016/j.econmod.2011.02.035

Barnea, A., Heinkel, R., & Kraus, A. (2005). Green investors and corporate investment. *Structural Change and Economic Dynamics, 16*(3), 332–346. https://doi.org/10.1016/j.strueco.2004.04.002

Bosquet, B. (2000). Environmental tax reform: does it work? A survey of the empirical evidence. *Ecological Economics, 34*(1), 19–32. https://doi.org/10.1016/S0921-8009(00)00173-7

Bovenberg, A. L., & De Mooij, R.A. (1997). Environmental tax reform and endogenous growth. *Journal of Public Economics, 63*(2), 207–237. https://doi.org/10.1016/S0047-2727(96)01596-4

Brock, W.A., & Taylor, M. S. (2005). Chapter 28 – Economic Growth and the Environment: A Review of Theory and Empirics. *Handbook of Economic Growth, 1,* 1749–1821. https://doi.org/10.1016/S1574-0684(05)01028-2

Ciaschini, M., Pretaroli, R., Severini, F., & Socci, C. (2012). Regional double dividend from environmental tax reform: An application for the Italian economy. *Research in Economics, 66*(3), 273–283. https://doi.org/10.1016/j.rie.2012.04.002

Chenghao, Y., Mayburov, I.A., & Ying, W. (2024). Fiscal Effects of Environmental Tax Reform: A Comparative Analysis of China, Germany and the United Kingdom. *Journal of Tax Reform, 10*(2), 258–270. https://doi.org/10.15826/jtr.2024.10.2.168

De Miguel, C., & Manzano, B. (2011). Gradual green tax reforms. *Energy Economics, 33,* S50–S58. https://doi.org/10.1016/j.eneco.2011.07.026

Durusu-Ciftci, D., Gokmenoglu, K. K., & Yetkiner, H. (2018). The heterogeneous impact of taxation on economic development: New insights from a panel cointegration approach. *Economic Systems, 42*(3), 503–513. https://doi.org/10.1016/j.ecosys.2018.01.001

Fan, Q., Qiao, Y., Zhang, T., & Huang, K. (2021). Environmental regulation policy, corporate pollution control and economic growth effect: Evidence from China. *Environmental Challenges, 5,* 100244. https://doi.org/10.1016/j.envc.2021.100244

Glomm, G., Kawaguchi, D., & Sepulveda, F. (2008). Green taxes and double dividends in a dynamic economy. *Journal of Policy Modeling, 30*(1), 19–32. https://doi.org/10.1016/j.jpolmod.2007.09.001

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics, 110*(2), 353–377. https://doi.org/10.2307/2118443

Hart, R. (2004). Growth, environment and innovation—a model with production vintages and environmentally oriented research. *Journal of Environmental Economics and Management, 48*(3), 1078–1098. https://doi.org/10.1016/j.jeem.2004.02.001

Hassan, M., Oueslati, W., & Rousselière, D. (2020). Environmental taxes, reforms and economic growth: an empirical analysis of panel data. *Economic Systems, 44*(3), 100806. https://doi.org/10.1016/j.ecosys.2020.100806

Holland, J. H. (2006). Studying complex adaptive systems. *Journal of Systems Science and Complexity, 19,* 1–8. https://doi.org/10.1007/s11424-006-0001-z

Hu, H., Dong, W., & Zhou, Q. (2021). A comparative study on the environmental and economic effects of a resource tax and carbon tax in China: Analysis based on the computable general equilibrium model. *Energy Policy, 156,* 112460. https://doi.org/10.1016/j.enpol.2021.112460

Hu, X., Wu, H., Ni, W., Wang, Q., Zhou, D., & Liu, J. (2023). Quantifying the dynamical interactions between carbon pricing and environmental protection tax in China. *Energy Economics, 126,* 106912. https://doi.org/10.1016/j.eneco.2023.106912

Isard, W. (1956). Regional science, the concept of region, and regional structure. *Papers in Regional Science, 2*(1), 13–26. https://doi.org/10.1111/j.1435-5597.1956.tb01542.x

Krugman, P. (1992). *Geography and trade.* MIT press. https://mitpress.mit.edu/9780262610865/geography-and-trade/ (Date of access: 15.03.2024).

Kumbhakar, S. C., Badunenko, O., & Willox, M. (2022). Do carbon taxes affect economic and environmental efficiency? The case of British Columbia's manufacturing plants. *Energy Economics, 115,* 106359. https://doi.org/10.1016/j.eneco.2022.106359

Lee, Y., & Gordon, R. H. (2005). Tax structure and economic growth. *Journal of Public Economics, 89*(5-6), 1027–1043. https://doi.org/10.1016/j.jpubeco.2004.07.002

Li, G., Zhang, R., & Masui, T. (2021). CGE modeling with disaggregated pollution treatment sectors for assessing China's environmental tax policies. *Science of the Total Environment, 761,* 143264. https://doi.org/10.1016/j.scitotenv.2020.143264

Liu, B., & Ge, J. (2023). The optimal choice of environmental tax revenue usage: incentives for cleaner production or end-of-pipe treatment? *Journal of Environmental Management, 329,* 117106. https://doi.org/10.1016/j.jenvman.2022.117106

Liu, G., Yang, Z., Zhang, F., & Zhang, N. (2022). Environmental tax reform and environmental investment: a quasi-natural experiment based on China's Environmental Protection Tax Law. *Energy Economics, 109,* 106000. https://doi.org/10.1016/j.eneco.2022.106000

North, D. C. (1990). *Institutions, institutional change and economic performance.* Cambridge University Press. https://doi.org/10.1017/CBO9780511808678

Oueslati, W. (2014). Environmental tax reform: Short-term versus long-term macroeconomic effects. *Journal of Macroeconomics, 40,* 190–201. https://doi.org/10.1016/j.jmacro.2014.02.004

Patuelli, R., Nijkamp, P., & Pels, E. (2005). Environmental tax reform and the double dividend: A meta-analytical performance assessment. *Ecological Economics, 55*(4), 564–583. https://doi.org/10.1016/j.ecolecon.2004.12.021

Pigou, A. C. (1920). *The Economics of Welfare.* Macmillan. https://oll.libertyfund.org/titles/pigou-the-economics-of-welfare (Date of access: 15.02.2024).

Rakpho, P., Chitksame, T., & Kaewsompong, N. (2023). The effect of environmental taxes and economic growth on carbon emission in G7 countries applying panel kink regression. *Energy Reports, 9,* 1384–1391. https://doi.org/10.1016/j.egyr.2023.05.185

Ren, Y., Hu, G., & Wan, Q. (2024). Environmental Protection Tax and Diversification Transition of Heavily Polluting Enterprises: Evidence from a Quasi-natural Experiment in China. *Economic Analysis and Policy, 81,* 1570–1592. https://doi.org/10.1016/j.eap.2024.02.031

Renström, T. I., Spataro, L., & Marsiliani, L. (2021). Can subsidies rather than pollution taxes break the trade-off between economic output and environmental protection? *Energy Economics, 95,* 105084. https://doi.org/10.1016/j.eneco.2020.105084

Sun, Y., Belgacem, S. B., Khatoon, G., & Nazir, F. (2023). Impact of environmental taxation, green innovation, economic growth, and renewable energy on green total factor productivity. *Gondwana Research.* https://doi.org/10.1016/j.gr.2023.10.016

Vellinga, N. (1999). Multiplicative utility and the influence of environmental care on the short-term economic growth rate. *Economic Modelling, 16*(3), 307–330. https://doi.org/10.1016/S0264–9993(99)00002-4

Wang, J., Wang, K., Shi, X., & Wei, Y. M. (2019). Spatial heterogeneity and driving forces of environmental productivity growth in China: would it help to switch pollutant discharge fees to environmental taxes? *Journal of Cleaner Production, 223,* 36–44. https://doi.org/10.1016/j.jclepro.2019.03.045

Wesseh Jr, P. K., & Lin, B. (2019). Environmental policy and 'double dividend' in a transitional economy. *Energy Policy, 134,* 110947. https://doi.org/10.1016/j.enpol.2019.110947

Xie, L., Zuo, S., & Xie, Z. (2023). Environmental protection fee-to-tax and enterprise investment efficiency: Evidence from China. *Research in International Business and Finance, 66,* 102057. https://doi.org/10.1016/j.ribaf.2023.102057

Zhang, X., Huang, Y., & Wei, F. (2024). The incentive effects of the macro tax burden on economic growth: A negative or positive incentive effect? Analysis based on panel data. *International Review of Economics & Finance, 93,* 128–147. https://doi.org/10.1016/j.iref.2024.03.006

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Conflict of interests

The authors declare no conflicts of interest.

Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Дата поступления рукописи: 09.04.2024.
Прошла рецензирование: 26.06.2024.
Принято решение о публикации: 27.09.2024.

Received: 09 Apr 2024.
Reviewed: 26 Jun 2024.
Accepted: 27 Sep 2024.