



Research on the Index Effect of Economic and Environmental Regulation in Guangxi Based on OLS Regression and TCA Algorithm

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Abstract. Taking the Guangxi listed companies of Shanghai and Shenzhen A shares in China from 2009 to 2019 as the research sample, this paper empirically tests the impact of environmental regulation on Guangxi's macro-economy by establishing OLS model. Firstly, the method of using the indicators of industrial sulfur dioxide, industrial wastewater emission and industrial smoke emission is constructed to standardize the comprehensive indicators of environmental regulation. The comprehensive index of environmental regulation (EVN) is calculated by stata15, and then OLS regression analysis is carried out. Furthermore, the endogenous problem is tested by TCA algorithm, which alleviates the possible endogenous problem in this paper. Besides, the problem of missing variables, confirms that environmental regulation can have a significant impact on the high-quality economic development of Guangxi, and puts forward relevant policy suggestions on the high-quality economic development direction of Guangxi.

Keywords: Green innovation · environmental regulation · high-quality development of Guangxi economy

1 Introduction

As socialism with Chinese characteristics enters a new era, China's economic development has entered a new normal, reform has entered a critical period and deep-water area, historical development has entered an important intersection period, and major changes have taken place in its international status and international environment. However, China's research on the impact of environmental regulation on high-quality economic development is mainly concentrated in the Yangtze River economic belt, Beijing Tianjin Hebei Urban Agglomeration and other areas, and most of the research contents focus on the connotation of regional high-quality development [1]. For example, Yan Borui and Dong [2] studied the five dimensions of China's high-quality development, made a macro and sub dimensional analysis of China's high-quality economic development, listed the economic objectives of China's high-quality development, put forward implementation suggestions for regional coordinated development, and further studied the impact of China's green dimension and economic development [2]. As another example, Li Chenggang [3] showed in the research on the high-quality development of China's

economy that government intervention and green technology innovation will promote green innovation, and green innovation is mainly affected by environmental regulation [3]. However, Chen Lingming [4] mentioned in his article on the high-quality development of regional industry and economy that the emergence of environmental regulation will lead to the invisible establishment of green entry barriers in the industry, and others who want to enter the industry will also face the green crowding out effect brought by environmental regulation [4]. Moreover, environmental regulation will force scientific and technological innovation and promote high-quality economic development with advanced and reasonable industrial structure. Promoting high-quality economic development is the only way for socialism with Chinese characteristics to enter a new era and China's economic development to enter a new stage; We should comprehensively and accurately grasp the basic connotation of high-quality development and jointly realize the transformation of promoting high-quality development at the two levels of ideological theory and concrete practice. There has been a lot of research on the impact of environmental regulation on the quality of economic growth, but the research on how environmental regulation affects the quality of economic growth and high-quality economic development has gradually attracted the attention of academia and government in recent years.

Furthermore, some scholars have shown that there is a critical value between environmental regulation and high-quality economic development, which will play an inhibitory role to a certain extent. For example, Chun L and Yingjie S. [5] studied the impact of environmental regulation on the quality of economic growth. Their research results can prove that the relationship between environmental regulation and high-quality economic growth is not linear, and there is an inflection point between them. After crossing this inflection point, the impact of environmental regulation on the quality of economic development has changed from the initial promotion effect to the inhibition effect, showing an inverted U-shaped relationship [5].

Therefore, this paper will analyze and study whether environmental regulation and green technology innovation drive the high-quality economic development of Guangxi. The research on these problems can not only provide a new policy perspective for the Guangxi government to promote the high-quality economic development, but also provide valuable experience for the environmental governance policy design of other cities, At the same time, it has important theoretical and practical significance for China's high-quality economic development [6].

2 Theoretical Background and Hypotheses

Green development is a hot topic in today's society under the encouragement of government policies, many enterprises take the pursuit of innovation as the goal and transform and upgrade their production mode in order to achieve the goal of green production. The high-quality economic development of Guangxi is inseparable from the input of technological innovation. From the perspective of production factors, the higher the level of technological innovation, the higher the efficiency of resource utilization, the higher the ratio of expected output to total output, and the lower the rate of unexpected output. In order to achieve the goal of high-quality economic development, Guangxi must pay attention to the development of green technology in the field of production. Therefore, there

is a new indicator in the field of green innovation environmental regulation. Environmental regulation shows that Guangxi attaches importance to ecology, and the intensity of regulation contributes to the green development of Guangxi enterprises to a certain extent. According to the relevant data of the National Bureau of statistics, Guangxi's regional GDP has maintained an upward trend in the past 20 years and achieved the goal of sustainable economic development. In the context of economic globalization, enterprises have strengthened green innovation, and replaced the traditional capital and labor by improving the efficiency of green innovation and acting on technological progress. Environmental regulation can improve the organic composition of industrial capital by improving the green technology level of an industry, and then promote enterprises to improve the original process level to improve the quality of products, so as to stimulate the improvement of the level of green technology innovation in the industry. Therefore, environmental regulation plays a certain role in promoting the development of economic quality in Guangxi. Based on the above theoretical analysis, we put forward a hypothesis:

Hypothesis 1. Environmental regulation index can significantly promote the economic development of Guangxi.

3 Materials and Methods

3.1 Data Descriptions

This paper selects the A-share listed companies in Guangxi, Shanghai and Shenzhen from 2009 to 2019 as the research sample. The data sources of this paper are as follows:

(1) *The total amount of industrial wastewater, sulfur dioxide and dust emissions in Guangxi, China are collected manually from Guangxi statistical yearbook and wind database;*

(2) *The GDP data of Guangxi comes from Guangxi Statistical yearbook, which is manually selected and collected;*

(3) The financial expenditure data of Guangxi comes from Guangxi statistical yearbook and is obtained through sorting (Table 1).

3.2 Core Explanatory Variable

Environmental regulation (ENV). Based on the practice of Ren Xiaosong [7], this paper calculates the comprehensive index of environmental regulation in Guangxi through the emission of three wastes and the entropy method. That is, the comprehensive index ENV of environmental regulation intensity is calculated by the industrial wastewater discharge per unit output value, industrial SO₂ discharge per unit output value and industrial soot discharge per unit output value. The greater ENV, the stronger the environmental regulation intensity. The specific calculation method of environmental regulation index is as follows:

Firstly, the industrial wastewater emission per unit output value, SO₂ emission per unit output value and industrial smoke emission per unit output value of cities in Guangxi

Table 1. Variable definition

Category	Variable		Data description
Intensity of environmental regulation	Primary index	Secondary index	
	Comprehensive index of environmental regulation	Industrial wastewater discharge	Total industrial wastewater discharge in Guangxi
		Industrial sulfur dioxide emission	Total sulfur dioxide emission in Guangxi
		Dust emission	Total soot emission in Guangxi
Quality of economic development	Guangxi GDP		Guangxi GDP

are standardized, and then the weight of various pollutants is calculated, so as to obtain the comprehensive index of environmental regulation intensity in Guangxi.

$$\begin{aligned}
 GE_{ij}^S &= [GE_{ij} - \min(GE_j)] / [\max(GE_j) - \min(GE_j)] \\
 W_j &= GE \sqrt{GE_{ij}} \\
 ENV_i &= \frac{1}{3} \sum_{j=1}^3 W_j GE_{ij}^S
 \end{aligned}$$

3.3 Model Setting

In order to test the above hypothesis, firstly, the following basic model is constructed for the direct transmission mechanism of environmental regulation on economic growth:

$$\begin{aligned}
 \text{growth: } GE_{ij}^S &= [GE_{ij} - \min(GE_j)] / [\max(GE_j) - \min(GE_j)] \\
 W_j &= GE \sqrt{GE_{ij}} \\
 ENV_i &= \frac{1}{3} \sum_{j=1}^3 W_j GE_{ij}^S \\
 GDP_{ij} &= \beta_0 + \beta_1 ENV + \varepsilon
 \end{aligned}$$

Where, GE_{ij} in Eq. (1) is the emission per unit output value of class j pollutants of city i in Guangxi, GE_{ij}^S is the standardization result of the index. $\max(GE_j)$ represents the maximum value of unit output value emission of class j pollutants in all cities, and $\min(GE_j)$ represents the minimum value of unit output value emission of class j pollutants in all cities. In Eq. (2), W_j represents the weight of various pollutants, GE_{ij} refers to the average emission level of the j -th pollutant per unit output value in Guangxi from 2009 to 2019. In Eq. (3), ENV_i is the comprehensive index of environmental regulation

intensity. In addition, formula (4) I represents the year of Guangxi, GDP represents the GDP index of Guangxi’s economic development in the past ten years, and ENV represents the comprehensive index of environmental regulation in Guangxi. In order to further discuss the impact of environmental regulation and green technology innovation technology on the economic development of Guangxi, the economic development level and comprehensive index of environmental regulation of Guangxi from 2009 to 2019 are selected for analysis.

4 Results and Discussion

4.1 Descriptive Statistics

Table 2 presents the descriptive statistical characteristics of all variables. The maximum and minimum values of environmental regulation factors in Guangxi are 0.937 and 0.44 respectively, indicating that there are certain differences in the degree of management and control invested in the activities of exploring the impact of economic development on the environment; The maximum and minimum government expenditure in different time periods are 200759 and 585096 respectively, indicating that there are differences in the focus of Guangxi on different areas of production and investment.

4.2 Basic Inspection and Analysis by OLS Regression

This paper uses stata15 to calculate the EVN comprehensive index of environmental regulation, and then carries out OLS regression analysis on the comprehensive index data of environmental regulation and GDP in Guangxi in the past ten years. The results of OLS regression analysis are shown in Table 3.

According to the test, we find that the environmental regulation index (ENV) of Guangxi in the test results is significant at the level of 1%, which shows that the environmental regulation index (ENV) of Guangxi plays a significant role in promoting the economic development of Guangxi.

4.3 Endogenous Problem by TCA Algorithm

Possible endogenous problems in this paper: there may be missing variables. There are many factors affecting environmental regulation. It is difficult to include all variables

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
YEAR	311	2014.817	2.855	2010	2019
ENV	311	.774	.129	.44	.937
PAY	311	401068.68	118200.18	200759	585096
GDP	311	15002.68	3918.765	8552.44	21237.14

Table 3. Regression results of test analysis

	GDP
ENV	27769.459***
cons	-6491.33***
Observations	311
R-squared	.837

Standard errors are in parentheses
 *** p < .01, ** p < .05, * p < .1

Table 4. Clustering effect test

	GDP
ENV	25540.023***
cons	-2691.701***
	(0)
Observations	311
R-squared	1

Standard errors are in parentheses
 *** p < .01, ** p < .05, * p < .1

into the secondary indicators of measurement in the empirical analysis of this paper. The impact of missing variables will be included in the residual term when calculated, so there is an endogenous problem. Consequently, this paper uses TCA algorithm to test the model, and the results are shown in Table 3.

It can be seen from the results in Table 4 that the explanatory variable coefficient symbol and significance level of the test are the same as those in Table 3 of the regression. It shows that the hypothesis is still supported under the control of time clustering effect.

4.4 Robustness Test

In order to ensure the reliability and scientific effectiveness of the test results, this paper decides to adopt the robustness test. The robustness test method used in this paper is to replace the explained variables. Replace Guangxi’s GDP with Guangxi’s fiscal expenditure (PAY). In theory, Guangxi fiscal expenditure can reflect the level of economic development in Guangxi to a certain extent. The benchmark model for robustness test is as follows:

$$PAY_i = \beta_0 + \beta_1 ENV_i + \varepsilon$$

The robustness test results are shown in Table 5.

In Table 5 of the robustness test results, it can be seen that the coefficient symbol of the estimated value of the test and the significance level of the test are still the same as

Table 5. Robustness test results

	PAY
ENV	838748.19***
cons	-248135.98***
	(16395.733)
Observations	311
R-squared	.839

Standard errors are in parentheses

*** $p < .01$, ** $p < .05$, * $p < .1$

the original test results. It can be seen from Table 5 that Guangxi's fiscal expenditure (PAY) is significantly positively correlated with environmental regulation index. The above robustness test results show that the hypothesis in this article has been statistically verified, so the research conclusions are more reliable.

5 Conclusion

Based on the exploration of the impact of Guangxi's environmental regulation on Guangxi's economic quality development, and using Guangxi's comprehensive index of environmental regulation from 2009 to 2019 as the measurement index of environmental regulation, this paper puts forward some relevant assumptions, such as that environmental regulation can have a significant impact on Guangxi's high-quality economic development and promote Guangxi's high-quality economic development. The comprehensive index of ENV environmental regulation and Stata data analysis software are calculated by Geoda software for scientific calculation. Through regression analysis, endogenous test and robustness test, the development of environmental regulation on the economic quality of Guangxi is tested. The main conclusions are as follows: there is a significant positive correlation between environmental regulation and the development of economic quality in Guangxi.

In the actual situation that environmental regulation can promote the development of economic quality in Guangxi, the government cannot blindly carry out intensive environmental regulation policies for all industries. It can appropriately implement differentiated environmental regulation policies, implement different environmental regulations for different enterprises and different regions, and discharge industrial pollutants in different batches to reduce pollution damage to the environment. Constantly explore the most appropriate environmental regulation index of environmental regulation on the economic quality development of Guangxi, and reasonably control the scope of environmental regulation index, which should not only meet the urgent needs of Guangxi for the development of economy by introducing enterprises, but also achieve the long-term goal of high-quality economic development, and pay attention to the sustainable development strategy.

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