



# Interaction Between Foreign Trade and Environmental Pollution: A Case Study of Guizhou Province, China

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## ABSTRACT

Economic globalization is deepening China's opening up to the world. China has promoted the development of foreign trade by extensively improving the level of its open economy. However, to determine whether the development of foreign trade has aggravated environmental pollution, attention needs to be paid. Taking Guizhou Province as an example, this study examines the relevant studies on the interaction between foreign trade and environmental pollution, and summarizes the current environmental pollution in Guizhou Province, and uses panel data at the municipal level of Guizhou Province from 2007 to 2016 to analyse the dynamic relationship between foreign trade and environmental pollution and further explore the environmental effect law of foreign trade. Results are found to be inconsistent with those of existing studies on the relationship between foreign trade and environmental pollution possibly due to the incorrect source of sample data and different estimation methods. The current situation of environmental pollution in Guizhou Province shows that the total discharge of industrial wastewater and industrial waste gas is on the rise and that the discharge of industrial solid waste increases in a small fluctuation. Emissions of environmental pollutants, gross domestic product, and foreign investment show a U-shaped relationship. Foreign trade layout affects the adjustment of the industrial structure, and its growth has resulted in negative effects. This study can provide a reference for understanding the internal relationship between trade and the environment, and diminishing the negative effects of foreign trade on the environment, and providing advice on environmental regulation, and promoting the coordinated development of trade and the environment in Guizhou Province.

## INTRODUCTION

China's economy continues to develop rapidly, with its total economic output ranking second in the world and its development achievements attracting worldwide attention. However, the extensive growth mode of China's economy has not been fundamentally changed. China's high economic growth comes at the cost of over-exploitation and inefficient utilization of natural resources and destruction of the environment. Notably, the reserve of natural resources and the environmental carrying capacity are limited. Environmental problems have become a major issue that hinders the sustainable development of China's economy. The total volume of import and export trade also continues to grow at a fast pace with the rapid development of the economy. These developments cause a series of problems, such as environmental pollution and ecological deterioration, which cannot be ignored. As a party engaging in trade openness, China's expansion of economic activities has increased resource consumption and damaged the ecological environment. Moreover, because of the large proportion of pollution-intensive products, the increase in export trade leads to a rise in pollution emissions.

Guizhou Province is one of the China's important provinces in the western region. With the advancement of China's opening up to the west and relying on its own energy advantages and industrial and agricultural bases, Guizhou has ushered its economy into a period of rapid development and has become an important energy and heavy industry base in the southwestern region of China. The foreign trade of Guizhou has developed rapidly, but its fragile environment exerts strong binding forces on economic development and opening up. The benefits attributed to the rapid growth of foreign trade have not kept pace with the growth, and the situation of resource waste and environmental pollution is becoming increasingly serious with the expansion of the trade scale. The negative effects of foreign trade have also become increasingly prominent. As shown in Fig. 1, the economic structure of Guizhou is unbalanced. Its economic development mode is defective, and its economic growth depends on the prolonged exploitation and utilization of natural resources, especially coal. Moreover, the environmental pollution accumulated through extensive economic growth is serious. Therefore, we must pay attention to the study of the relationship between foreign trade and environment. Taking Guizhou Province as an example,

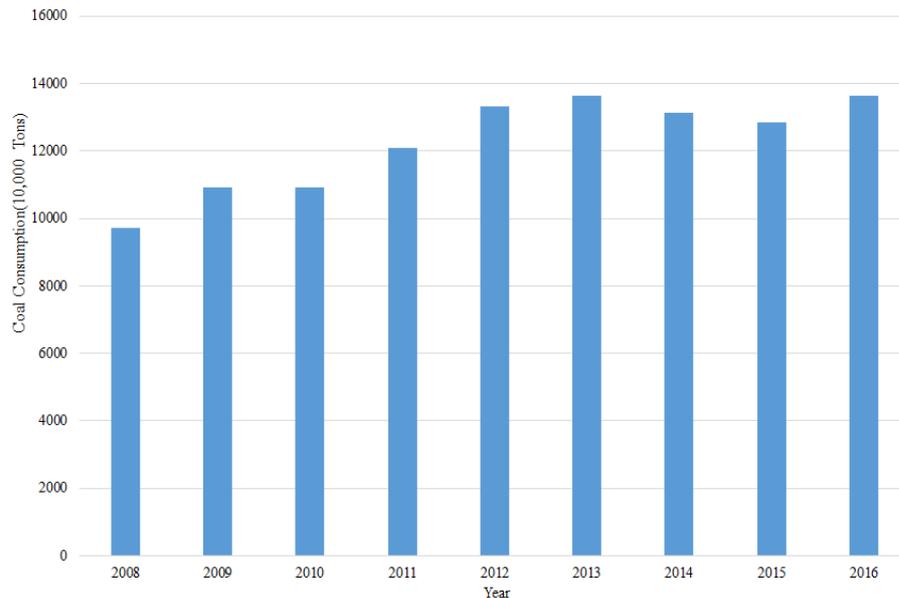


Fig. 1: Coal consumption in Guizhou Province from 2008-2016.  
(Data from the China Statistics Database, <http://data.stats.gov.cn/index.htm>)

this study identifies the relationship between foreign trade and the environment, and determines the means to achieve coordinated development, and establishes Guizhou into an economic development-oriented and environment-friendly society to promote the coordinated development of the opening up policy and the environment.

### EARLIER STUDIES

Foreign research on foreign trade and the environment began early, and the research results are abundant. However, the research conclusions still lack consistency. The numerous complex issues involved in the relationship between foreign trade and environmental quality have been heatedly debated in the international academia. Discussing the environmental effects of trade at the theoretical level and studying the relationship among economic growth, trade openness, and environmental pollution can enrich theoretical contents. Grossman et al. (1991) believed that the positive and negative impacts of scale, structural, and technological effects determine whether the impact of foreign trade on environmental pollution was positive or negative. Birdsall et al. (1993) believed that development of foreign trade expanded the economic scale, thus directly increasing environmental pollution. Considering the principle of comparative advantage, Copeland et al. (1995) argued that the impact of foreign trade on the environment was that pollution-intensive industries were transferred from developed to developing countries or from countries with strong environmental control to those with weak

environmental control. By comparing Mexico and Chile, two countries with different degrees of development, Beghin et al. (1995) found that the trade openness led to increased pollution to the ecological environment regardless of the degree of development. Copel et al. (1995) studied the trading system of emission permits and concluded that the development of free trade led to increased emissions of global pollutants. Azhar et al. (2007) investigated the relationship between changes in the industrialization patterns of foreign trade and specialization and environmental pollution. McAusland et al. (2013) compared the different impacts of Chinese and international trade on the environment and reported that the former and the latter increase and decrease pollution emissions, respectively. Erdogan (2014) analysed the impacts of international productivity differences on environmental quality and found that complete free trade could help reduce pollution levels in member countries of the Organisation for Economic Cooperation and Development and that approximately half of the reduction was from international productivity differences. Cherniwchan et al. (2016) summarized the literature on linkages between international trade and the environment and provided the structure of this review by linking changes in emissions with those in production activities at all levels in factories, companies, and industries. Copeland (2016) reviewed recent studies on the implications of endogenous policies on the impact of trade on environmental sustainability and the stock of renewable resources. He reported that pollution policies were recognized as endog-

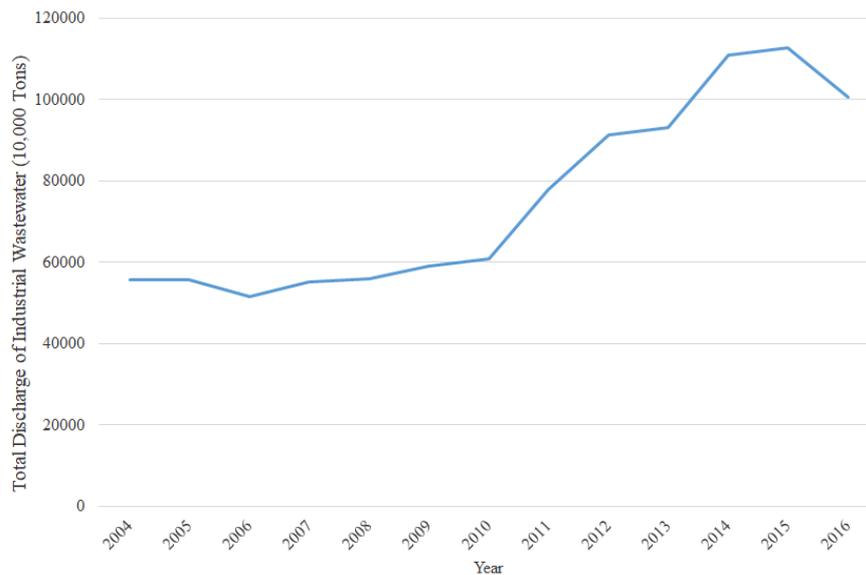


Fig. 2: Total discharge of industrial wastewater in Guizhou Province from 2004-2016. (Data from the China Statistics Database, <http://data.stats.gov.cn/index.htm>)

enous. The study of Cherniwchan (2017) showed that trade liberalization decreased the number of plants affected by pollutants. The 2/3 reduction in PM10 and SO2 emissions from manufacturing in the United States between 1994 and 1998 could be attributed to trade liberalization. Bildirici et al. (2017) explored the relationship among environmental pollution, economic growth, and energy consumption of hydropower under the different economic cycle systems of the G7 countries during 1961-2013. The studies of Duan et al. (2017) were based on the World Input-Output Database and used the revised terms of trade (PTT) index. The results showed that the change in global trade pattern is an important driving force behind the different changes in PTT. Sakamoto et al. (2017) studied the relationship between environment-related efficiency and export performance, and the empirical results showed that efficiency has a minimal impact on export performance in industries with relatively low freedom, and the impact of efficiency depends on industry characteristics. Wang et al. (2017) discovered that international exports and inter-provincial trade increased the health burden of air pollution in China's inland underdeveloped provinces. In China's effective regional air quality planning, trade plays an important role but is often easily ignored. The conclusions of existing research on the relationship between foreign trade and environmental pollution level are inconsistent, possibly because of the different sources of sample data and various estimation methods. Therefore, taking Guizhou Province as an example, this study establishes dynamic panel data at the municipal level in Guizhou Province, and analyses the relationship between

foreign trade and environmental pollution, and draw conclusions of their relationship from the perspective of empirical research. In addition, this work proposes suggestions for environmental regulations and policies and for the trade and economic development of Guizhou. This study has practical importance for the coordinated development of the economy and the environment in Guizhou Province.

## CURRENT SITUATION OF ENVIRONMENTAL POLLUTION IN GUIZHOU PROVINCE

### Water Pollution

Guizhou Province is experiencing a serious shortage of water resources. The per capita water resource possession is lower than the national average level, and the distribution of water resources is seriously uneven. Guizhou Province is located in China's inland, and the lack of ocean vapour leads to the shortage of water resources. Aside from water shortage, Guizhou also suffers from widespread water pollution. The discharge of industrial wastewater is an important reason behind the aggravated water pollution. As shown in Fig. 2, the total discharge of industrial wastewater in Guizhou Province increased from 2004 to 2016 and reached 128.0312 million tons in 2015, with an average annual growth rate of 6.74%. As shown in Table 1, the content of main pollutants in industrial wastewater decreases yearly, which indicates that Guizhou Province has effectively reduced the content of major pollutants in industrial wastewater by strengthening the treatment of industrial pollutants and upgrading the technology of industrial emission reduction.

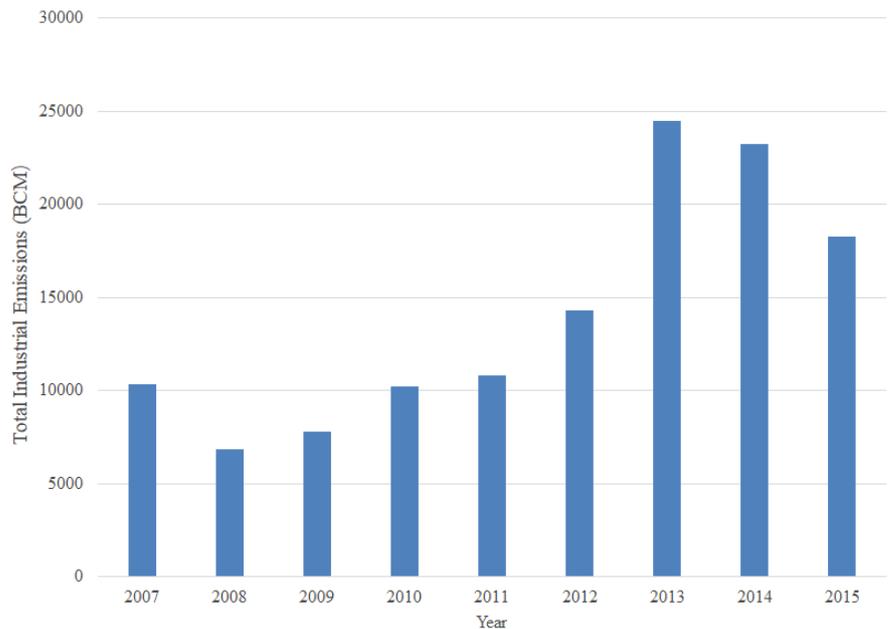


Fig. 3: Total emissions of industrial waste gas in Guizhou Province from 2007-2015. (Data from the EPS Data Platform, <http://olap.epsnet.com.cn>)

### Air Pollution

Energy mining and coal-heavy chemical enterprises in Guizhou Province cause serious air pollution. In several small- and medium-sized enterprises, pollutant smuggling occasionally occurs, resulting in frequent air pollution problems, such as smog, in winter and spring. As shown in Fig. 3, the main pollutant emissions from industrial exhaust in Guizhou Province increased from 10.356 billion standard cubic meters in 2007 to 2446.6 billion standard cubic meters in 2013 then decreased in 2014 and 2015. Overall, the industrial exhaust emissions in Guizhou Province have been increasing.

### Solid Waste Pollution

The discharge of industrial solid waste in Guizhou Province increased steadily in a small fluctuation from 598.588 million tons in 2007 to 935.599 million tons in 2017. The average annual growth rate of industrial solid waste production is 5.62%. Overall, industrial solid waste production slightly increased annually before 2013 and sharply increased in 2015, then remained at a high level. The overall upward trend is evident (Fig. 4).

## EMPIRICAL RESEARCH

### Econometric Model

Considering the factors related to data availability in Guizhou Province, an econometric model of panel data is established as shown in Formula (1).

$$\ln Z_{it} = \alpha_1 \ln Y_{it} + \alpha_2 (\ln Y_{it})^2 + \alpha_3 \ln FDI_{it} + \alpha_4 (\ln FDI)^2 + \alpha_5 \ln TR_{it} + \alpha_6 \ln ST_{it} + c + \varepsilon_{it} \quad \dots(1)$$

Where  $it$  represents the corresponding data of city  $i$  in  $t$  year and  $Z_{it}$  represents the pollutant discharge situation of city  $i$  in  $t$  year. In this study, “solid” is used to represent the production of industrial solid wastes, and “water” is used to represent the discharge of industrial wastewater.  $Y_{it}$  is the GDP output of city  $i$  in  $t$  year.  $FDI_{it}$  indicates the foreign direct investment of city  $i$  in  $t$  year.  $TR_{it}$  expresses the foreign trade situation of city  $i$  in  $t$  year, reflecting the scale effect.  $ST_{it}$  expresses the industrial structure of city  $i$  in  $t$  year, reflecting the structural and product effects.  $c$  represents the intercept term, and  $\varepsilon_{it}$  denotes the error term.

### Data Sources and Explanations

According to the specific situation of Guizhou Province, this study uses the dynamic panel data of cities at all levels to conduct an empirical analysis of the impact of environmental pollution on trade. On the basis of the statistical data of six prefecture-level cities and three autonomous prefectures in Guizhou Province from 2007 to 2016, this study analyses the relationship between foreign trade and the environment of cities' panel data in Guizhou Province. The statistical data on GDP, industrial wastewater discharge, industrial solid waste production, foreign investment, foreign trade, and related influencing factors are mainly from the State Statistical Yearbook of Guizhou (<http://www.gz.stats.gov.cn/>).

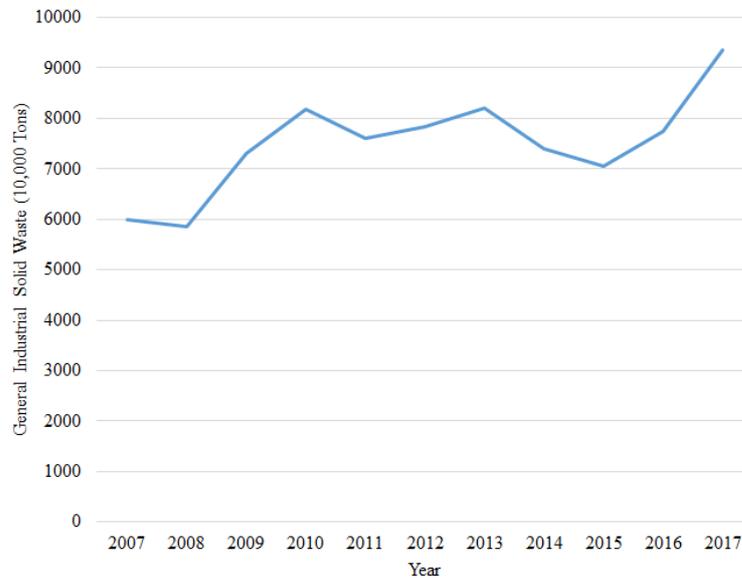


Fig. 4: General industrial solid waste in Guizhou Province from 2007-2017. (Data from the Zhongjing Statistical Database, <http://db.cei.cn>)

### Result Analysis

A fixed-effect regression model is established by using the research methods adopted by most studies. Three models, namely, hybrid, individual fixed-effect, and time fixed-effect models, are used for the analysis. The specific regression results are shown in Table 2.

The following conclusions are obtained from Table 2:

1. A U-shaped relationship exists between environmental pollutant emissions and GDP in Guizhou Province, that is, the income and scale effects of economic growth are initially reduced, and then increased pollutant emissions. Given that the environment has a certain self-purification capacity, the discharge of pollutants within this capacity range does not cause environmental pollution, which belongs to the free use of the environment (the marginal environmental cost is zero). Therefore, "zero pollution" does not conform to the principles of environmental economics.
2. The growth of foreign investment and the discharge of industrial solid wastes and wastewater in Guizhou Province show an inverted U-shaped change. This conclusion verifies the environmental Kuznets curve hypothesis that short-term foreign investment results in negative technological effects, and the growth of foreign investment increases the discharge of industrial wastewater and the production of solid wastes. However, in the long run, given that foreign direct investment leads to advanced technology and production management standards, and pollu-

tion emissions gradually decrease when the emission peaks.

3. The layout of Guizhou's foreign trade and economy affects the adjustment of the industrial structure. The product and structure effects show significant negative effects. The increase in industrial proportion caused by foreign trade promotes the growth of industrial solid waste and industrial wastewater. Statistically significant estimates show that for Guizhou Province, when the proportion of the industrial output value to GDP is large, the emissions of industrial pollutants measured by different indicators are low.
4. The negative scale effect of Guizhou's foreign trade growth is consistent with the current theory of "polluter's paradise," which supports the establishment of the hypothesis in Guizhou Province. Guizhou's foreign trade belongs to the "high energy consumption, high pollution, and resource-based" export mode. For a long time, processing trade has been the main mode, with low added value of export manufactured goods and poor terms of trade. The vast majority of Guizhou's foreign trade is composed of resource, pollution, and emission intensive industries. The growth of Guizhou's foreign trade and the extensive foreign trade model have placed tremendous pressure on Guizhou's ecological, environmental and resource systems and increased other pollutant emissions.

### POLICY RECOMMENDATIONS

#### Expanding the Participation in Foreign Trade and Ac-

Table 1: Emissions of major pollutants from industrial wastewater in Guizhou Province from 2011-2016. (Data from the China Statistics Database, <http://data.stats.gov.cn/index.htm>)

Index	2016	2015	2014	2013	2012	2011
Chemical oxygen demand emissions (10,000 tons)	25.59	31.83	32.67	32.82	33.3	34.22
Ammonia nitrogen emissions (10,000 tons)	3.08	3.64	3.8	3.83	3.87	3.98
Total nitrogen emissions (10,000 tons)	4.25	4.76	4.7	4.38	4.68	4.44
Total phosphorus emissions (10,000 tons)	0.39	0.48	0.49	0.44	0.45	0.45
Petroleum emissions (tons)	136.61	412.76	330.79	437.39	461.81	483.83

Table 2: Regression results.

Explanatory variable	Solid			Water		
	Hybrid model	Individual fixed-effect model	Time fixed-effect model	Hybrid model	Individual fixed-effect model	Time fixed-effect model
C	-1.621	2.012*	-1.201	1.641***	8.241*	0.412
$\ln Y_{it}$	1.012*	0.614*	1.654*	1.325*	-0.254*	1.245*
$(\ln Y_{it})^2$	0.001	0.004*	-0.142*	-0.064	0.017	0.006*
$\ln FDI_{it}$	0.214	0.541***	-0.541	0.674	0.034	0.011***
$(\ln FDI_{it})^2$	-0.026*	-0.012*	-0.154*	0.004*	-0.741*	0.019*
$\ln TR_{it}$	-0.214*	0.141**	-0.364*	-0.087**	0.011**	-0.697*
$\ln ST_{it}$	0.245*	0.110*	0.003*	0.451	0.234*	0.221*
R-squared Adjusted	0.741	0.904	0.845	0.421	0.931	0.845
AIC	1.801	0.354	1.647	2.221	0.108	1.414
SC	1.845	0.641	1.845	2.303	0.478	1.254
DW	0.147	0.365	0.098	0.654	0.574	0.109

(In the table, \*, \*\* and \*\*\* indicate significance at 1%, 5% and 10% levels, respectively)

### celerating the Opening Up

The scale of import and export trade in Guizhou Province is gradually expanding. Heavy industries, such as petroleum and minerals, account for a large proportion of the industry and provide a small contribution to foreign trade. By contrast, light industries, such as textile and garment, account for a small proportion of the industry and a large proportion of foreign trade commodities. We should further study and develop the strategy of opening up to the west, change geographic and resource advantages into the actual driving force of economic development, and establish trade cooperation with other countries. In addition, investment attraction should be increased, and the scope of foreign capital utilization should be broadened. Innovating technology, building a brand, and realizing the sound and rapid development of foreign trade are crucial. Furthermore, the export of products from high-polluting industries should be reduced, and the comparative advantages of production factors in Guizhou Province should be fully utilized, and a sustainable development route of trade development and ecological environment coordination in Guizhou Province should be realized.

### Adjusting the Structure of Import and Export Products to Reduce Environmental Damage

Guizhou Province should pay attention to the marketing of green products in the international market during the development and production of its own green products and take this as a guide to promote the optimization and upgrading of the export structure. To further improve the construction of a green food standard system and strengthen the management of green food labels, international registration of green food trademarks must be conducted in an organized manner; the selection and certification of the origin of raw materials must be carefully examined, and follow-up supervision and management should be performed. In the development of green food, attention should be provided to the development, introduction, and screening of production methods to tackle key technical problems and form a means of green food production and its supporting technical service system. Attention should also be provided to expanding the scale of green products, continuously optimizing products, enriching varieties, and steadily promoting the pace of market construction to gradually occupy and expand the international market scale.

### **Formulating Proper Import and Export Strategies and Setting Proper Environmental Standards**

The growth mode of foreign trade, especially the structure of import and export products, should be changed. The export of self-owned brand products must be expanded with environmental protection technologies, and the export of highly polluting products must be controlled, and imports of advanced production technologies, environmental protection technology, and equipment from abroad should be encouraged. In foreign trade, the research, development, and introduction of clean production technology should be emphasized, and the green industry should be supported, and the production and export of green products should be developed. In addition, we should give appropriate tax credit preferences and prohibit the import of technologies and equipment that seriously pollute the environment. Proper environmental standards can put pressure on the export of polluting products, thus reducing the pollution intensity of export products. Exports can also efficiently pass the strict environmental standards of developed countries, thereby reducing the number of local enterprises that fail to reach foreign countries. The economic loss caused by the return of environmental standards can be reduced, and a good reputation can be established for products in the international market.

### **Optimizing the Self-Investment Environment and Developing the Environmental Protection Industry**

Guizhou Province should strive to improve its own environment, including its natural and investment economic environments. The quality of the environment should be improved by making the environment an important means of attracting foreign investment, and sustainable development of environmental protection should be realized by expanding the use of foreign capital. Efforts to protect the natural environment must be intensified, and improvement of the fragile ecology of Guizhou should be attempted to prevent difficulties in introducing foreign capital due to the harsh natural environment. Efforts should be exerted to improve the management system related to the introduction of foreign capital, enhance the quality and efficiency of government services, and create a fair market environment, an open and transparent legal environment, and an efficient and nondiscriminatory administrative environment for the maximal use of foreign capital. At present, the main environmental protection scheme is the development of new clean energy. The market potential of clean energy is large. The excessive consumption of resources can be inferred as a broad market prospect of emerging energy. Many countries currently regard environmental protection as a key industry, in which the policy support is strong and the emphasis

is strengthened. Attention should also be provided to pollution control equipment, technology, services, energy saving, and bio-energy development.

### **CONCLUSIONS**

In the early and middle stages of the sustainable development of foreign trade, China provided too much attention to economic interests and neglected the cost of the environment and resources. Therefore, China welcomed a large number of industries with high pollution, emissions, and energy consumption, which has resulted in a long-term surplus in foreign trade and a deficit in natural resources and has affected the sustainable development of the economy and environment. Taking Guizhou Province as an example, this study explores relevant studies on the interaction between foreign trade and environmental pollution, and summarizes the current situation of environmental pollution in Guizhou Province, and analyses the dynamic relationship between foreign trade and environmental pollution by using panel data at the municipal level of Guizhou Province from 2007 to 2016. Specific measures are introduced to control environmental pollution. The results show that the different sources of sample data and various estimation methods used in Chinese and foreign studies led to the inconsistency of existing conclusions on the relationship between foreign trade and environmental pollution. The main manifestations of environmental pollution in Guizhou Province are evident in the rising trends of industrial wastewater discharge, waste gas discharge, and solid waste discharge with a small fluctuation. The panel data regression model confirms that the relationship among environmental pollutant emissions, GDP, and foreign investment in Guizhou Province is U-shaped. The layout of the foreign trade economy affects the adjustment of the industrial structure. The growth of foreign trade has also exerted a negative scale effect. Therefore, further studies should be conducted in the following aspects: increasing the emission targets of environmental pollutants, prolonging the length of the study objects, and investigating the short-term impact principle of environmental pollution and foreign trade at different economic levels. Moreover, the construction of the coordination mechanism of international environmental and economic policies is worth studying.

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