

Research Article

Evaluation of Economic Benefits and Ecological Environment Impact of Export Trade in Anhui Free Trade Zone

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Nowadays, the scale of international trade is expanding at a great pace, leading to the development of the economy of different countries. Global industrialization and urbanization are developing with each passing day, and this fast economic expansion is putting a tremendous impact on the environment. Like the other countries, the scale of Chinese export trade is also increasing with time, resulting in the stable economy of our country. With the improvement of living standards, people are continuously demanding high environmental facilities. Further, the impact of trade (enterprises, companies, industries, etc.) on the ecological environment has become a worldwide problem because economic progress brought forth by trade expansion may directly affect the environment by causing pollution to rise or the degradation of natural resources. This indeed is a serious issue; therefore, various countries have started focusing on the impact of export trade on the ecological environment. In recent years, the issue of economic benefits and the environmental impact of export trade has become a hot topic of research. Therefore, this study focuses on the relationship between trade, economy, and environmental quality in China. For the accomplishment of our research study, we selected Anhui free trade zone (FTZ) as an example to analyze the interaction between the economic benefits of Anhui export trade and the local environment. It is among the top trading provinces in China having a faster economic development. In order to accurately study the economic benefits and environmental impact of export trade in the Anhui FTZ, this paper selects industrial waste gas, wastewater, and solid waste to establish an export trade environmental impact indicating system. After comparative analysis, three factors that include industrial soot (dust) emissions for export trade, chemical oxygen demand for trade, and general industrial solid waste dumping and discards are selected to evaluate the impact on the environment of the free trade zone. Based on this, the export trade environment vector autoregressive (VAR) model is established, and the variance decomposition method is used to analyze the dynamic impact of various factors on the environmental impact index. Further, we established an economic benefit VAR model based on the export economic benefit index (EI), export value (EV), and export product concentration (EPC) index and judged the economic benefit of the Anhui free trade zone based on the contribution rate of the obtained three factors. The experimental results show that the export volume and product concentration directly affect the economic benefits of the region, and at the same time, the expansion of export trade promotes the growth of economic benefits.

1. Introduction

A free trade zone (FTZ), also known as a foreign trade zone, is referred to as an area where products can be imported in, handled, manufactured, or modified and then re-exported without the involvement of customs authorities [1]. The rapid development of international trade has accelerated the realization of globalization [2]. The world economy is

undergoing transformation and adjustment. Therefore, the impact of trade on the ecological environment has become a worldwide problem because the economic progress brought forth by trade expansion may directly affect the environment by causing pollution to rise or the degradation of natural resources [3]. The uncoordinated development of economic benefits of export trade and the environment as well has become increasing severely. The export trade in China has

developed rapidly, its scale has been increasing, and its position in global trade is improving gradually [4, 5]. The development of export trade has enabled the economy of China to maintain steady growth. The import and export volume of China in 2020 reached 4646.32 billion Yuan, which increased by 1.5% as compared with the previous year [6]. The proportion of industrial products in the foreign trade product structure is increasing continuously. In 2020, the export value of industrial products was 2.475202 billion Yuan, of which 95.5% of industrial products were exported [7].

World trade development has elevated the problem of the relationship between trade and the ecological environment. Accelerating the development of import and export trade leads to a significant effect on the economy [8]. The in-depth analysis reveals that the development of import and export trade has a serious impact on the ecological environment [9]. According to the analysis of the export product structure in China, the export trade products manufacturing industries produce high pollution and consume a huge amount of energy [10]. Domestic energy consumption continues to increase. Through the analysis of the energy structure, coal is still the most used energy source. Consuming a large amount of coal energy materials emits a large number of pollutants into the atmosphere, pollutes the air environment, and also pollutes water resources [11]. There were 21 free trade zones in China according to a report generated by the Chinese ministry of commerce in 2021 [12]. In this study, we chose Anhui free trade zone as an example to analyze the interaction between the economic benefits of Anhui export trade and the local environment.

Anhui province is near the sea and river, and the city clusters along the river reach eight hundred miles. It is the area where the economic sectors are connected to each other. The 8th most populated province in China is Anhui. It is the 12th most inhabited province among the 34 provinces in China and based on the area it is the 22nd biggest province of China [13]. The total area of the Anhui pilot free trade zone is 119.86 square kilometers. There are three areas in Anhui pilot free trade zone, namely, Hefei, Wuhu, and Bengbu. Each area consists of 64.95 square kilometers, 35 square kilometers, and 19.91 square kilometers, respectively. Therefore, with the establishment of the three free trade zones in Anhui province, the export trade volume has increased and the economy has developed rapidly. The overall export trade of Anhui province has maintained a state of increasing year by year. However, economic development has brought serious environmental pollution problems, and the discharge of industrial wastewater, waste gas, and solid pollutants has continued to increase. The total import and export trade of Anhui province in 2010 was 24.28 billion US dollars. In 2020, the total import and export trade volume reached 78.7 billion US dollars with an average annual growth of 4.95 billion US dollars, and the economic growth rate was relatively high over the same period. So, import and export trade is an important factor that affects economic growth.

This study selects Anhui province's export trade economic index, export value, and export product

concentration from 2010 to 2020 and establishes a vector autoregressive (VAR) model. This study uses the variance decomposition technique to study the relationship between export trade and economic growth in the Anhui trade zone to accurately analyze the impact of Anhui's export trade on economic growth and to achieve a healthy growth state between Anhui's export trade and economic growth. Through the evaluation and analysis of the economic benefits and environmental impact of the Anhui free trade zone, this study is conducted to accelerate the long-term and stable development of the Anhui free trade zone's export trade and also maintain an attractive image in the process of international trade. This study analyzes the economic benefits and environmental impression factors of the Anhui free trade zone through the establishment of a VAR model and combines the impact of environmental benefit factors and economic benefit factors on the regional economy. This research work finds a balance maintained economic growth without causing damage to the environment, which is conducive to promoting the development of Anhui province's export trade and achieving coordinated development with the environment. Figure 1 shows the free trade zones in China.

The main contributions of this study are as follows: (1) in this study, we selected the Anhui free trade zone as an example to analyze the interaction between the economic benefits of Anhui export trade and the local environment. (2) In order to accurately study the economic benefits and environmental impact of export trade in the Anhui free trade zone, this study selects industrial waste gas, wastewater, and solid waste to establish an export trade environmental impact indicating system. On the basis of this, we established an export trade environment vector autoregressive (VAR) model and used the variance decomposition method to analyze the dynamic impact of various factors on the environmental impact index. (3) We closed our study with a summary of the economic benefits and ecological environment impact of export trade in the Anhui free trade zone.

The rest of the article is structured as follows: Section 2 lays out the literature review, Section 3 represents the materials and methods, and Section 4 illustrates the results and discussion. Finally, in Section 5, we conclude our research study.

2. Related Work

FTZ is an important means of adapting to globalization and establishing a comparative advantage in global trade. Since the suggestion of the FTZ concept, research has focused on its policy effects as well as the relationship between FTZ and novelty and economic growth. According to the innovation-driven vision of FTZ, it clearly contributes to and enables the capacity for regional innovation [14]. When the FTZs initially became popular, the majority of researchers examined their effects on cities from the angles of finance, commerce, foreign direct investment, and green development. From the financial point of view, Yao and Whalley [15] believe that the economic liberalization and floating exchange rate policies introduced by the FTZ increase capital liberalization and

China's free trade zones

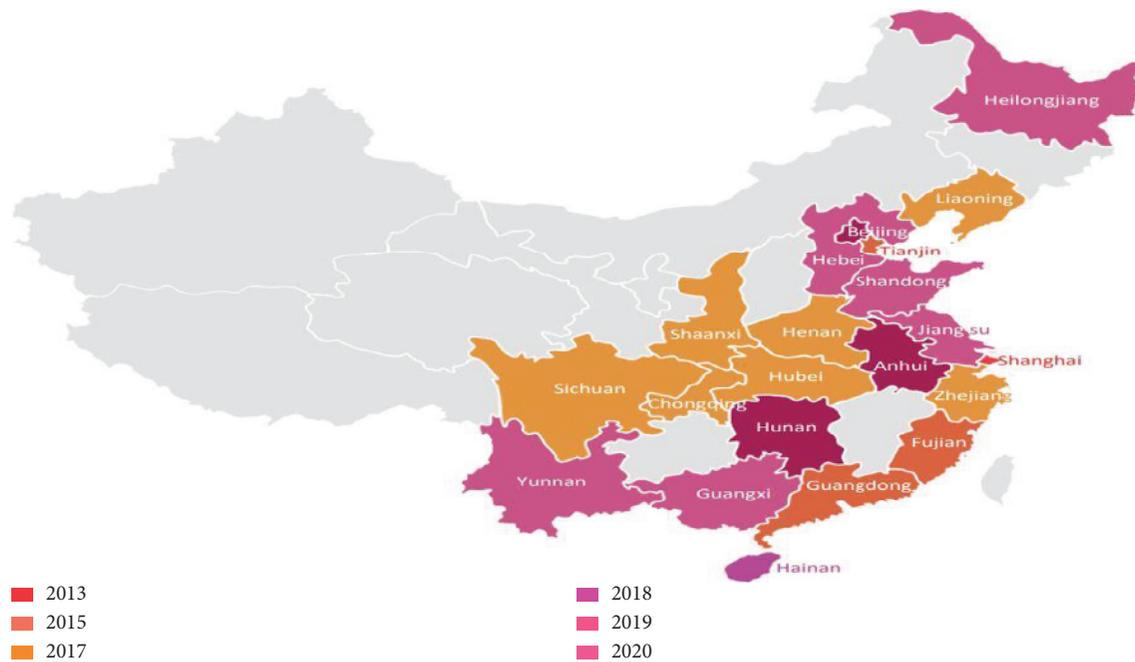


FIGURE 1: Free trade zones in China.

encourage financial openness. Jiang et al. [16] investigated the overall impact of the formation of the China (Shanghai) pilot free trade zone (SPFTZ) on green total factor productivity (GTFP) in Shanghai using synthetic control techniques based on microscopic data. The experimental results show that in Shanghai SPITZ has promoted the GTFP. Hongyan Wang et al. [3] analyzed the effect of China (SPFTZ) on GTFP in the YRDUA using data from Yangtze-river delta urban agglomeration (YRDUA) from 2003 to 2018. It examines the influence mechanism using the regression discontinuity (RD) approach and the mediating effect model. Lin Fan et al. [17] analyzed the evaluation of Hefei's economic and technical development area to measure the effectiveness of industrial symbiosis.

The relationship between commerce, the Chinese economy, and environmental quality was analyzed by Zhou [18]. The environmental efficacy of thirty Chinese provinces and cities was calculated using the Super-SBM model in the context of these interactions to determine the levels of regional inequality. Li and Yeung conducted research on regional economic development in China and concluded that the existence of global corporations will increase regional development disparities in the context of globalization [19]. He [20] used an empirical dynamic panel data model to examine whether financial reform may have an impact on exports or not. Using two estimating techniques (OLS and GMM), they concluded that the variable representing financial deregulation is positive and insignificant at the 5% level. Lin et al. [21] created cross-sectional spatial regression and panel and spatial regression models to investigate the stimulating impacts of financial development on economic growth in China. They concluded that while some areas of the financial sector may have a beneficial impact on economic growth, the impact of other sectors is uncertain.

From the summary of existing research, it is found that worldwide industrial development has increased recently and this rapid economic growth has severely stressed the environment. Therefore, the impact of trade on the ecological environment has become a worldwide problem, because trade expansion and economic progress directly affect the environment by causing pollution to rise or the degradation of natural resources. The issue of trade and the environment has become more serious as global trade has grown. The economy is affected by blindly accelerating the growth of import and export trade. China is the world's largest exporting country. Because of this, not only China's environment is suffering, but China also significantly contributes to global environmental degradation. If we do not follow the coordinated development of environmental protection and opening and only pursue the scale and quantity of export products, then it will seriously damage the ecological environment in China. In this paper, we analyzed the evaluation of economic benefits and ecological environment impact of export trade in the Anhui free trade zone of China.

3. Materials and Methods

3.1. Study Area and Data Collection. Anhui province is located in the east of China, next to the coastal provinces of Jiangsu and Zhejiang. Hefei is the capital of the Anhui province. There are three areas in Anhui PFTZ, namely, Hefei, Wuhu, and Bengbu. The total area of the Anhui province is 140,200 km². It is the area where the economic sectors are connected to each other. In this study, we select the export data of Anhui province as the research object and collected the export data from the "Anhui Statistical Yearbook" 2010–2020. Pollutant emissions data is obtained from the "China Environmental Yearbook." Figure 2 shows the location of Anhui province.



FIGURE 2: Map of the research area.

3.2. *Establishment of an Environmental Impact Indicator System for Export Trade in Anhui FTZ.* In the process of establishing the environmental impact indicator system for export trade in Anhui FTZ, this study selects industrial wastewater, industrial waste gas, and solid waste. Chemical oxygen demand for export trade, industrial smoke (dust) emissions, and general industrial solid waste dumping and discarding are further selected as the basic indicators. Table 1 shows the specific indicators used in this study.

3.3. *Establishment of a VAR Model for the Export Trade Environment in Anhui FTZ.* The VAR model is built on the bases of statistical analysis. Its main goal is to anticipate the correlation time series between the variables, assess the time series between distinct variables, and treat all endogenous variables in the system as functions of the lag value of other variables. After conflicts occur, other variables in the system are also affected. The following equation is used for the establishment of a VAR model:

$$\begin{aligned} \begin{Bmatrix} y_{1t} \\ y_{2t} \\ \dots \\ y_{kt} \end{Bmatrix} &= \Phi_1 \begin{Bmatrix} y_{1t-1} \\ y_{2t-1} \\ \dots \\ y_{kt-1} \end{Bmatrix} + \dots + \Phi_p \begin{Bmatrix} y_{1t-p} \\ y_{2t-p} \\ \dots \\ y_{kt-p} \end{Bmatrix} \\ &+ H \begin{Bmatrix} x_{1t} \\ x_{2t} \\ \dots \\ x_{dt} \end{Bmatrix} + \begin{Bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \dots \\ \varepsilon_{kt} \end{Bmatrix}, \quad t = 1, 2, \dots, T. \end{aligned} \quad (1)$$

The following equation represents its vector representation:

$$y_t = \Phi_1 y_{t-1} + \dots + \Phi_p y_{t-p} + Hx_t + \varepsilon_t, \quad t = 1, 2, \dots, T. \quad (2)$$

TABLE 1: Environmental impact index system of export trade.

First-level indicator	Secondary indicators
Environmental indicators	Chemical oxygen demand for export trade
	Industrial smoke (dust) emissions
	General industrial solid waste dumping and discarding

In the above equation, y_t represents the k -dimensional endogenous variable column vector, x_t describes the d -dimensional exogenous variable column vector, p shows the lag order, and T illustrates the actual number of samples. Variable “ H ” represents the k -dimensional disturbance vector, and it is the coefficient matrix to be estimated in the $k \times k$ -dimensional matrix and the $k \times d$ -dimensional matrix. ε_t represents the k -dimensional disturbance vector.

In this paper, we established a VAR model to analyze the export trade environment of Anhui FTZ. This model analyzes the impact of various influencing factors on the environmental index through variance decomposition and impulse response methods. It sets NI to represent the environmental impact index and PE to represent the proportion of export pollution. The following equation represents the environmental VAR model constructed in this paper, where c represents the exogenous variables of the model:

$$\begin{aligned} \begin{pmatrix} NI_t \\ PE_t \end{pmatrix} &= \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} + \Phi_1 \begin{pmatrix} NI_{t-1} \\ PE_{t-1} \end{pmatrix} + \dots \\ &+ \Phi_p \begin{pmatrix} NI_{t-p} \\ PE_{t-p} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}, \quad t = 1, 2, \dots, T. \end{aligned} \quad (3)$$

In the above equation, “ p ” represents the interval order and “ T ” represents the number of samples. In the 2×2 -dimensional matrix, “ Φ_1, \dots, Φ_p ” describes the coefficient

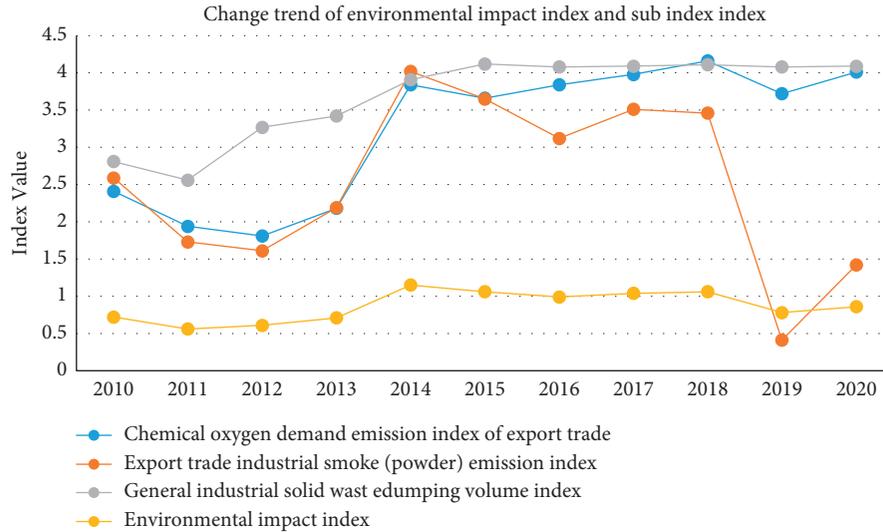


FIGURE 3: The environmental impact indicators and subindices of Anhui province's export trade from 2010 to 2020.

matrix with estimates, and ε_t shows the 2-dimensional disturbance column vector.

3.4. *Establishment of an Economic Benefit VAR Model for Anhui FTZ.* In order to study the economic benefits of export trade in the Anhui FTZ, we proposed a VAR model for Anhui FTZ. In this model, "EI" represents the economic efficiency index of export trade, "EX" shows the export value, and "EXS" illustrates the concentration of export products. After taking the natural logarithm of EX, $\ln EX$ is obtained. This model analyzes the dynamic structural relationship among the indices of Anhui FTZ. The following equation represents an economic benefit VAR model:

$$\begin{pmatrix} EI_t \\ \ln EX_t \\ EXS_t \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \\ c_3 \end{pmatrix} + \Phi \begin{pmatrix} EI_{t-1} \\ \ln EX_{t-1} \\ EXS_{t-1} \end{pmatrix} + \dots + \Phi_p \begin{pmatrix} EI_{t-p} \\ \ln EX_{t-p} \\ EXS_{t-p} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{pmatrix}, \quad t = 1, 2, \dots, T. \tag{4}$$

In equation (4), "P" represents the interval order and "T" illustrates the number of samples.

In 4×4 -dimensional matrix, " Φ_1, \dots, Φ_p " represents the coefficient matrix with estimation, and ε_t describes the 4-dimensional disturbance column vector.

4. Results and Discussion

4.1. *Results of Environmental Impact Analysis of Anhui FTZ.* According to the established proposed environmental impact assessment index system of Anhui province export trade, we collected and sorted out the original data of Anhui province from 2010 to 2020 and then normalized each index to obtain the corresponding weight index. Further, we drew

the environmental index with the trend of subindices, as shown in Figure 3.

According to the above line graphs of industrial soot (dust) emissions, chemical oxygen demand, and general industrial solid waste dumping and discarding from export trade in Anhui Province FTZ, the three index curves are basically the same. Only industrial soot (dust) emissions were low in 2019 with an index of 0.41, which shows that all three indicators affect the environmental index. 2014 is the year with the highest industrial soot (dust) emissions of the three indicators in the Anhui FTZ from 2010 to 2020. The energy consumption of Anhui province in 2014 reached 125 million tons of standard coal and the energy consumption increased by 2.7% compared to the previous year. The exports of Anhui reached 31.52 billion US dollars, which increased 11.6% year by year. The rapid development of such enterprises has increased energy consumption, which caused the emissions of these three indicators to increase. The environmental impact index has been in a stable state from 2010 to 2020, in which only the environmental impact index exceeded 1 in 2014, 2015, 2017, and 2018, and the rest were less than 1, which indicates that the environmental impact index was exported during these four years. The emissions of soot (dust) from the trade industry, the chemical oxygen demand for trade, and the dumping and disposal of general industrial solid waste have a greater impact on the Anhui FTZ.

4.2. *Results of Environmental Benefits of Export Trade in Anhui FTZ.* Based on the established VAR model of the environmental benefits of export trade in Anhui FTZ, this study substitutes the above environmental impact subindices of Anhui province from 2010 to 2020 into the VAR model and uses the variance decomposition method to analyze the dynamics influences of different factors on the environmental impact index. Figure 4 shows the contribution rate of the economic impact index and the proportion of export pollution to the environmental impact index. The abscissa is

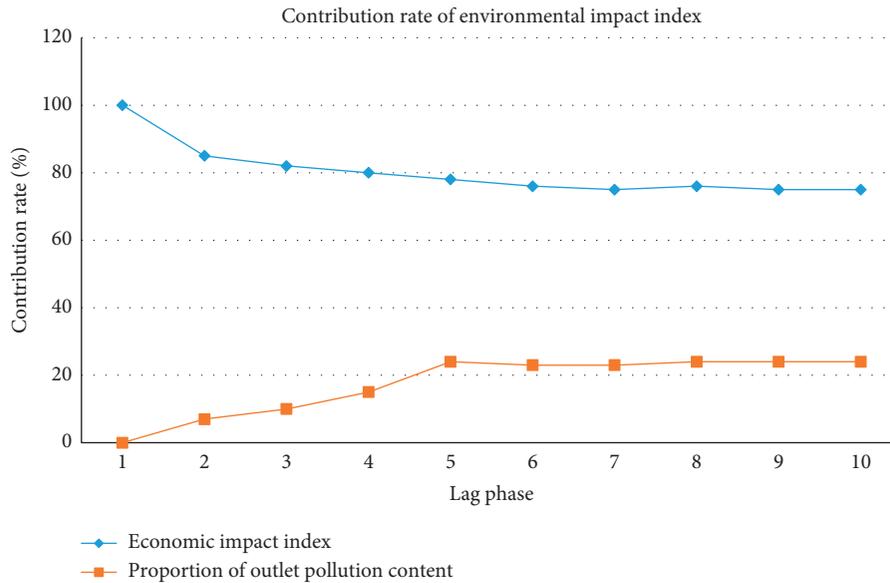


FIGURE 4: The contribution rate of the economic impact index and the proportion of export pollution to the environmental impact index.

the lag period of the impact, and the ordinate is the contribution rate of each variable to the change of the environmental impact index.

Figure 4 shows the contribution rate of the economic impact index and the proportion of export pollution to the environmental impact index. According to the data used in Figure 4, the environmental impact index itself changes. The contribution rate of the environmental impact index from the first to the fifth period is in a state of continuous decline. Since the sixth period, the contribution rate has been maintained at about 76% and is in a stable state. From the second lag period, the contribution of the export pollution content to the environmental impact index has continuously increased and reached its peak value in the fifth lag period. Since then, the contribution rate has been around 24%. The data show that the proportion of export pollution has a promoting effect on the environmental impact. The export environmental index of the Anhui province FTZ and the proportion of export pollution maintained a stable relationship with each other.

4.3. Results of Economic Benefits of Export Trade in Anhui FTZ.

In this study, the Anhui FTZ export economic benefit index (EI), export value (InEX), export product concentration (EXS), and other indexes are substituted into the established economic VAR model for the correlation analysis. The results show that the correlation coefficient between EI and InEX was 0.97, and the correlation coefficient between EI and EXS was 0.89, which indicates that the correlation between the economic benefit index, export value, and product concentration is strong. Here we used variance decomposition analysis to study the degree of co-occurrence of economic benefit index, export value, and export product concentration. The obtained results are shown in Figure 5. The horizontal axis is the lag period

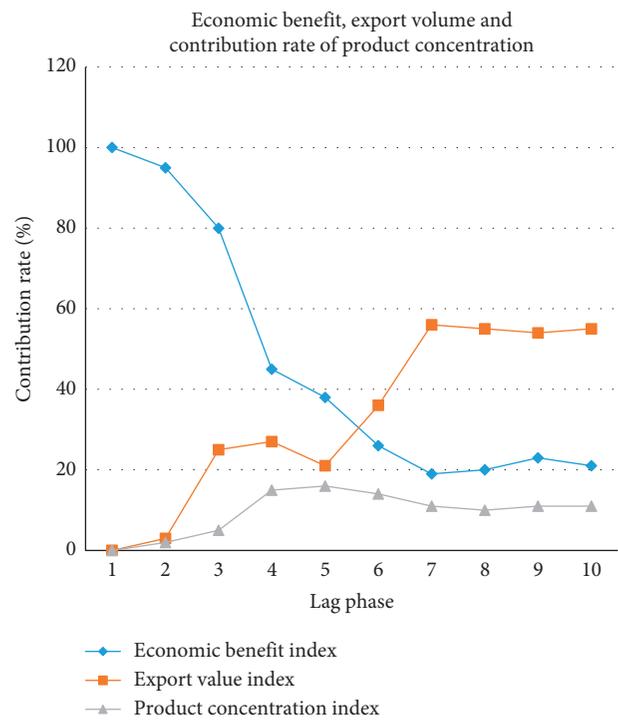


FIGURE 5: Contribution rate of economic benefit index, export value, and product concentration index.

of the impact effect, and the vertical axis represents the contribution rate of the variable to the change of the social benefit index.

From Figure 5, we conclude that the economic benefit index's change contribution is in a state of decline from the first period to the seventh period, and after that, it maintains at about 19%. The export value contributed most to the change in the economic benefit index. From the first to the seventh period, it maintained a rapid increase and thereafter

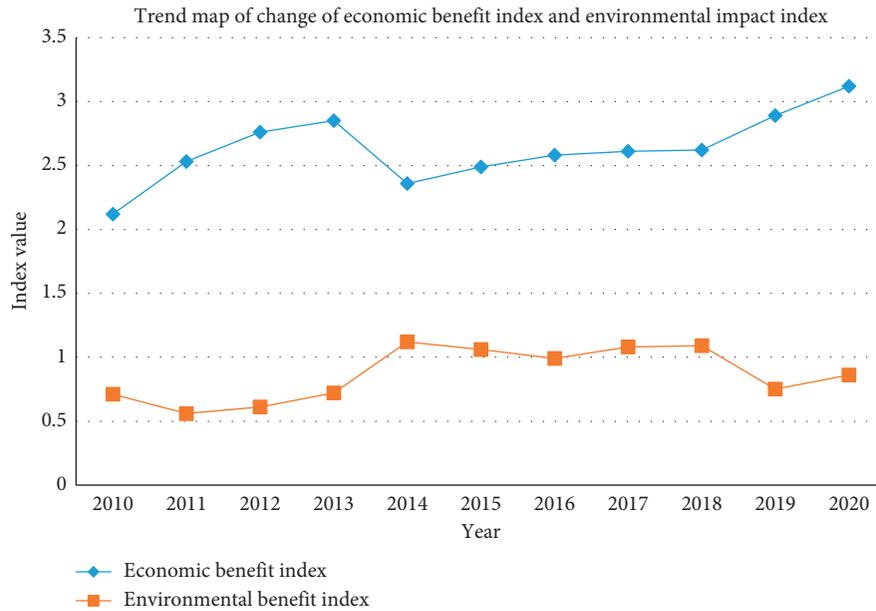


FIGURE 6: The change trend of the economic benefit index and environmental impact index from 2010 to 2020.

the contribution rate remained at about 56%. The contribution of export product concentration to the economic benefit index has gradually increased from the first period to the seventh period by about 11%. Based on the analysis of the results, the economic index of export trade in Anhui FTZ is increasing, and the export volume and product concentration index directly affect economic benefits. The scale of export trade promotes the rapid growth of economic benefits. If the export value is changed, the corresponding export trade-economic benefit index and product concentration also show a linear change. After the economic benefit index is changed, the corresponding product concentration also changes. Hence, it can be concluded that the economic benefits of export trade in the Anhui FTZ are in a state of continuous growth.

4.4. Comprehensive Analysis of Export Economic Benefits and Environmental Impact of Anhui FTZ. Based on the above data analysis, the export economic benefits and environmental impact data of the Anhui FTZ are obtained. The export trade data of Anhui province from 2010 to 2020 is analyzed, and finally, the export trade-economic index and environmental impact index are obtained. Figure 6 shows the change trend of the economic benefit index and environmental impact index from 2010 to 2020.

Observing the above economic benefit index and the environmental impact index change trend chart, we can conclude that the export trade-economic index of Anhui FTZ is generally rising and the environmental benefits fluctuate up and down. The relationship between these has a positive correlation and after calculating the correlation coefficient between these indexes is 0.65. As the economic benefit index increases, the environmental impact index also continues to rise. Therefore, under the premise that the

export trade of the Anhui FTZ brings economic benefits to the region, it will also cause environmental pollution to a certain extent.

4.5. Discussion. The relationship between the economic index of export trade and the environmental index of the Anhui FTZ from 2010 to 2020 has been declining which indicates that the industry in the Anhui FTZ during this period is dominated by high pollution. The rapid development of export trade causes environmental pollution. The positive correlation changes between the economic benefit index and environmental impact index indicators from 2011 to 2014 prompted the positive correlation between the economic benefits of the Anhui FTZ and the environmental impact index. These positive correlations indicate that the “energy-saving and emission reduction” measures in Anhui production areas have achieved initial results. The Anhui zone’s export trade industry has changed from a traditional high-polluting industry to a low-polluting export trade zone.

After the reform and opening, Anhui province’s labor and resources have played an important role in export trade and shown rapid growth in export trade. However, from the perspective of environmental quality, the impact on export trade is relatively low. In the process of analyzing the impact of environmental quality and natural resources on trade volume, the export resources are regarded as a fixed value and the negative external effects caused by pollution affected the market pricing mechanism.

5. Conclusion

In this paper, we select Anhui FTZ to analyze the interaction between the economic benefits of Anhui export trade and the local environment. In order to accurately study the

economic benefits and environmental impact of export trade in Anhui FTZ, first of all, we collected and sorted out the original data of Anhui province from 2010 to 2020 and then normalized each index to obtain the corresponding weight index. In this paper, we proposed an evaluation index system for the environmental impact of the Anhui export trade based on three indicators which include industrial soot (dust) emissions for export trade, chemical oxygen demand for trade, and general industrial solid waste. The analysis results show that the three indicators of the Anhui FTZ in 2014 had the largest emissions. In the same year, the environmental impact index also reached 1.15 which is the highest in 11 years indicating that the three indicators have a great impact on the environmental impact index. Further, we also proposed a VAR model for the economic benefit of export trade in the Anhui FTZ using the variance decomposition method to analyze the contribution rate of the economic benefit index, export volume, and export product concentration index. The experimental and analysis results show that the contribution rate of the economic benefit index's change contribution has been in a state of decline from the first period lag period to the seventh period and after that maintained at about 19%. The contribution of export product concentration to the economic benefit index has gradually increased from the first period to the seventh period by about 11%, indicating that the export value is changing with time. The export value contributed the most to the change in the economic benefit index. From the first period to the seventh period, there was a rapid increase, and thereafter, the contribution rate remained at about 56%. Through a comprehensive analysis of the export economic benefits and environmental impact of the Anhui FTZ, we observed that the correlation coefficient between the economic benefit index and the environmental impact index was 0.65. As the economic benefit index increases, the environmental impact index also continues to rise. Therefore, under the premise that the export trade of the Anhui FTZ brings economic benefits to the region, it also causes environmental pollution to a certain extent.

Data Availability

The data used to support this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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