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Research on Driving Factors of Low-Carbon Development in Fujian Province

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Abstract. Based on the data related to carbon emissions in Fujian Province from 2000 to 2021, factor analysis and regression analysis were used to explore the key factors affecting low carbon development in Fujian Province. The results show that carbon emissions in Fujian Province are closely related to a variety of factors, including the consumption level of residents, international trade, urbanization, population size, fixed asset investment, energy intensity and economic development level, which have a relatively large impact on carbon emissions in Fujian Province, while the energy structure and industrial structure have a relatively small impact. Through the empirical analysis, we propose corresponding solutions to the current problems in order to promote the low-carbon development of Fujian Province.

1. Introduction

China is now the world's highest carbon emitter, contributing up to a quarter of the global emissions, and in 2020, the Chinese government has issued a call for a commitment to peak carbon dioxide emissions by 2030 and to work towards achieving carbon neutrality by 2060 as a means of promoting sustainable development in the face of global climate change [1]. Different provinces in China have different levels of development, and the "carbon peaking and carbon neutrality" target needs to be implemented in a regional distribution.

In August 2016, Fujian Province was listed as one of the first national ecological civilization pilot zones, and one of its goals is to build Fujian Province into a green cycle low-carbon development pilot zone. In addition, during the 14th Five-Year Plan period, Fujian Province will focus on the "carbon peaking and carbon neutrality" goals, emphasizing carbon emission reduction as a fundamental measure, vigorously promoting green and low-carbon development, and striving to achieve sustainable development. And, during the 14th Five-Year Plan period, it will strive to reduce CO2 emissions per unit of GDP by 13.5%.

The economic level of Fujian Province has been improving in recent years, with rapid growth in comprehensive strength. In 2021, the total economic volume of Fujian Province ranks eighth in China with 4.88 trillion. However, with the rapid economic growth, resource scarcity, environmental pollution and a series of other problems have emerged. In order to achieve sustainable development in Fujian Province, it is necessary to continuously improve the quality of the environment on the basis of sustained economic growth [2]. In-depth exploration of the influencing factors of low-carbon economic development in Fujian Province will provide an important theoretical basis for formulating a more effective low-carbon development policy, which will promote sustainable development. It also provides a reference for other provinces in China to explore the green and low-carbon development path.

2. Literature Review

There is a wealth of research on the factors influencing carbon emissions. Most of the studies have focused on economic development, industrial structure, energy structure, population size, etc. Li and Xiao [3] conducted an in-depth study of carbon emissions in Wuxi from 1995 to 2008 using principal component analysis. Based on the carbon emissions of Wuxi in previous years, an assessment model was constructed using six indicators as influencing factors, including primary industry, secondary industry, tertiary industry, total social fixed asset investment, total retail sales of social consumer goods, and fiscal expenditure. Niu and Zhang et al [4] used the STIRPAT model based on carbon emission data of Liaoning Province from 1999-2019 to investigate the effects of six factors on carbon emissions in Liaoning Province, including population, urbanization rate, GDP per capita, and energy consumption per unit of GDP, coal consumption share, and value-added share of secondary industry. And Wang et al [5] studied China's CO2 emissions from 1957 to 2000 by log-mean Dixie decomposition method, and the results showed that economic development leads to the increase of carbon emissions, while energy intensity is the key factor to reduce carbon emissions. And this study introduces the factors of foreign trade and the consumption level of residents, considering the specific geographical location

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and the people' consumption scale of Fujian Province.

There are also many methods to explore the influencing factors, such as principal component analysis, factor analysis, multiple linear regression, etc. And the combination of LMDI factor decomposition method and STIRPAT method is more commonly used in the study of the influencing factors of carbon emissions. Yang and Tan [6] used principal component analysis and concluded that the driving force of low-carbon economic development in Hunan Province mainly comes from economic efficiency factors. Liu [7] studied various factors affecting carbon emissions in China by LMDI factor decomposition method, and used scenario analysis to analyze carbon emissions in different contexts. Cao et al [8] used an extended multiplier structure decomposition method to identify the overall and regional carbon intensity changes in China from multiple levels, and decomposed the carbon intensity changes into input structure effect, intensity effect, and final demand effect. And this study first used factor analysis to extract the public factors, and then used linear regression models to explore the magnitude of each influencing factor's contribution to carbon emissions in Fujian Province.

3. Factor Analysis and Regression Analysis

3.1. Variable Selection and Data Sources

In this paper, 2000-2021 are selected as the study years, and all the data required for factor analysis are obtained from the Statistical Yearbook of Fujian Province, while the carbon emissions in Fujian Province are obtained from the China Carbon Accounting Database. Among them, the carbon emission data are only updated to 2019, so the research period of regression analysis is 2000-2019. Since the selected evaluation indicators have positive and negative contributions to the low-carbon economy, the relevant data are positivized using the negative method in this paper.

This paper construct a carbon emission impact factor evaluation index system consisting of nine indicators, as shown in Table

Table 1. Carbon emission impact factor evaluation index system.

Influencing Factors	Indicators	Symbol	Calculation
Economic Factors	Level of economic development (RMB)	X1	GDP per capita
	Industrial structure (%)	X2	Secondary industry GDP/tertiary industry GDP
	Fixed asset investment (billion RMB)	X3	Direct data
	International trade (billion RMB)	X4	Net exports
Demographic factors	Population size (million people)	X5	Total resident population
	Urbanization rate (%)	X6	Urban population/total resident population
Energy factors	Energy structure (%)	X7	Coal consumption/total energy consumption
	Energy intensity (million tons of standard coal/billion yuan)	X8	Total energy consumption/regional GDP
	Market factors Resident consumption level (yuan)	X9	Resident consumer price index

3.2. Factor Analysis

Factor analysis is a statistical method that transforms multiple indicators into a small number of uncorrelated and unobservable random variables, i.e., factors, by studying the internal structure of the correlation coefficient matrix of the original data in order to extract the vast majority of information about the original indicators [9], i.e., dimensionality reduction.

First, the KMO and Bartlett tests were performed on the data of the nine indicators using SPSS. According to the test results, the KMO value reaches 0.817, and its correlation coefficient is lower than 0.05, which indicates that it has passed the Bartlett sphere test, thus proving that the variables proposed in this paper have good factor analysis ability. And the common degree of all variables is above 90%, which indicates that the evaluation results of factor analysis on carbon emission intensity are better.

By using SPSS, this paper conducted a factor analysis of the nine indicators and summarized the results of the two common factors, including the overall variance and the cumulative contribution. The eigenvalue of the first factor F1 after rotation was 6.793, explaining 75.477% of the total information. Similarly, the eigenvalue of the second factor F2 is 1.796, which explains 19.961% of the total information. The cumulative contribution of the variance of these two eigenvalues is 95.438%, which is greater than 85%, so it is appropriate to choose to keep the two common factors to evaluate the carbon emission intensity.

The rotated factor loadings matrix is shown in Table 2. It can be seen that: common factor F1 has large loadings on economic development level, fixed asset investment, international trade, population size, urbanization rate, energy intensity, and residential consumption level, so it can be defined as a comprehensive factor; common factor F2 has relatively large loadings on industrial structure and energy structure, so it can be defined as a structural factor.

Table 2. Rotated factor loading matrix

Indicators	Symbol	F1	F2
Level of economic development (RMB)	X1	0.939	0.327
Industrial structure (%)	X2	0.099	0.961
Fixed asset investment (billion RMB)	X3	0.943	0.327
International trade (billion RMB)	X4	0.981	0.102
Population size (million people)	X5	0.973	0.216
Urbanization rate (%)	X6	0.943	0.312
Energy structure (%)	X7	0.592	0.645
Energy intensity (million tons of standard coal/billion yuan)	X8	0.951	0.237
Resident consumption level (yuan)	X9	0.979	0.181

According to Table 2, the expressions of each principal component factor are as follows:

$$F1=0.939X1+0.099X2+0.943X3+0.981X4+0.973X5+0.943X6+0.592X7+0.951X8+0.979X9 \quad (1)$$

$$F2=0.327X1+0.961X2+0.327X3+0.102X4+0.216X5+0.312X6+0.645X7+0.237X8+0.181X9 \quad (2)$$

3.3. Regression Analysis

The common factors and their scores, as shown in Table 3, were obtained by multiple regression analysis with Fujian's annual carbon emissions as the dependent variable, F1 and F2 as independent variables. Among them, R = 0.977, adjusted R2 = 0.950, F = 181.241, the significance is 0. The regression equation is:

$$F=73.285F1+7.341F2+184.473 \quad (3)$$

$$F=71.215X1+14.310X2+71.508X3+72.641X4+72.892X5+71.398X6+48.120X7+71.434X8+73.075X9 \quad (4)$$

Table 3. Factor score coefficient matrix

Indicators	Symbol	F1	F2
Level of economic development (RMB)	X1	0.128	0.032
Industrial structure (%)	X2	-0.236	0.811
Fixed asset investment (billion RMB)	X3	0.129	0.031
International trade (billion RMB)	X4	0.198	-0.175
Population size (million people)	X5	0.166	-0.074
Urbanization rate (%)	X6	0.133	0.018
Energy structure (%)	X7	-0.037	0.403
Energy intensity (million tons of standard coal/billion yuan)	X8	0.155	-0.050
Resident consumption level (yuan)	X9	0.177	-0.106

4. Conclusion and Suggestion

From the regression model, it can be seen that carbon emissions in Fujian Province are influenced by a variety of factors, the most important of which are the level of residential consumption, international trade and population size in the comprehensive factor. Each unit increase in resident consumption level, international trade and population size will cause an increase of 73.075, 72.641 and 72.892 units of carbon emissions in Fujian Province, respectively. The average annual growth rate of disposable income per capita in Fujian Province is 8.5%, and reaching 40,659 yuan in 2021, ranking 7th in China. Adequate disposable income has greatly increased the consumption level of people in Fujian Province, which also makes the carbon emissions continue to increase. With the acceleration of global economic integration, international trade has become a key driver of global economic development, and also one of the main factors affecting global CO2 emissions. In particular, Fujian Province has seen a sharp rise in carbon emissions due to the export of a large number of high carbon emission and high energy consumption products. The energy consumption caused by various human activities is the direct cause of carbon emissions. The increasing population size of Fujian Province also leads to the continuous growth of its carbon emissions. In addition, urbanization and energy intensity also have a great influence on carbon emissions in Fujian Province. Currently, with the continuous urbanization, the infrastructure demand in Fujian Province is increasing, which requires the consumption of a large amount of highly polluting resources, such as steel, fossil energy and cement. On the other hand, due to the rising living standards of urban residents and the development of technology, their lifestyles have also changed dramatically, leading to an increase in the consumption of commodities with high carbon content [10]. As energy intensity continues to diminish, energy use efficiency is also increasing, which will help to significantly reduce carbon emissions due to energy consumption. The change in energy intensity has greatly contributed to the reduction of carbon emissions in Fujian Province, so improving energy efficiency is also an important way to slow down the growth rate of carbon emissions.

The influence of energy structure and industrial structure on carbon emissions in Fujian Province is relatively small. Each unit increase in energy structure and industrial structure will cause a change of 48.120 and 14.310 in carbon emissions, respectively. The smaller

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impact of these two factors on carbon emissions in Fujian Province is mainly due to the energy resource endowment of Fujian, where coal has been the main source of energy used, and not yet been changed. Among the three major industries, the carbon emitted by the output value of secondary industry is the most and the carbon emitted by the output value of tertiary industry is the least. Fujian Province has rich tourism resources, so the government actively promotes the development of the tertiary industry with tourism as the core, and attaches importance to optimizing the industrial structure. In terms of energy, Fujian Province has a variety of clean energy sources such as wind, light, water, gas and nuclear, etc. In 2021, State Grid Fujian Electric Power will focus on the goal of "carbon peaking and carbon neutrality", plan a new power system demonstration area at the provincial level, accelerate the construction of a clean and low-carbon energy system, and actively contribute to the construction of "Clean Fujian". Therefore, although reducing the proportion of secondary industry, increasing the proportion of tertiary industry, and reducing the proportion of coal fuel in total energy consumption can reduce carbon emissions, the impact on carbon emissions in Fujian Province is relatively small.

Therefore, this paper can make the following suggestions to reduce carbon emissions in Fujian Province: (1) Guiding and regulating the consumption patterns of residents and green and low-carbon consumption concepts, including reducing waste and encouraging the purchase of new energy vehicles, etc. (2) Improving the way of foreign trade and reducing the import and export of high energy-consuming and high-emission products. (3) Improving energy use efficiency through reward and punishment policies. Adopting advanced technology to improve the level of energy utilization, encourage and promote energy recycling, and further play the role of new dynamic energy and new industry support. (4) Developing a carbon emission reduction action plan suitable for Fujian Province. The nine prefecture-level cities in Fujian Province have different resource status and economic development levels. In order to effectively reduce carbon emissions, Fujian Province should conduct a comprehensive assessment of energy consumption, carbon emissions and pollution emissions based on the regional characteristics of each prefecture-level city in order to develop a carbon emission reduction action plan that meets the local reality and implement it into relevant policies [11].

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