Analysis and Research on Causality between Carbon Emission and Structural Optimization Based on Linear and Nonlinear Granger Causality Test

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Abstract. Although the tourism industry is booming, its scale imbalance, structural imbalance and inefficient allocation of resources have hindered the realization of the high-quality development goals of the regional tourism industry. Therefore, it is very important to optimize the tourism industry structure. This paper uses linear and nonlinear Granger causality tests to study the relationship between ' tourism industrial structure optimization ' and ' carbon dioxide emissions ' in 31 provinces in China. The results show that : (1) There is a nonlinear Granger two-way causal relationship between ' tourism industrial structure optimization ' and ' carbon dioxide emissions '. (2) With the acceleration of the upgrading and rationalization of the tourism industry structure, structural optimization and adjustment will help reduce carbon dioxide emissions. In addition, reducing carbon emissions can also promote the upgrading and rationalization of the tourism industry structure.

1 INTRODUCTION

In recent years, more and more scholars have begun to study the relationship between industrial structure evolution and energy conservation and emission reduction, and explore how to achieve emission reduction targets in the process of structural adjustment. However, a considerable part of the existing domestic research is still in the stage of qualitative theoretical analysis. In view of this situation, it is necessary to use quantitative analysis method to explore the relationship between tourism industrial structure upgrading and carbon dioxide emissions from the perspective of causality. In the current domestic quantitative research based on the ' EKC hypothesis ', most of the studies implicitly assume that the upgrading of the tourism industry structure will only bring one-way changes in carbon dioxide emissions, while ignoring that there may be other causal directions between the two. However, the traditional Granger causality test method has limitations in exploring this complex causal relationship. Therefore, in future research, more quantitative analysis methods are needed to explore the two-way causal relationship between the upgrading of tourism industrial structure and carbon dioxide emissions, and to find more accurate test methods. This will help to better guide the adjustment of the tourism industry structure and achieve the goal of energy conservation and emission reduction. However, due to the impact of factors such as market changes, cultural effects, changes in consumption structure, and advances in science and technology, the relationship between ' tourism industrial structure upgrading ' and ' carbon dioxide emissions ' is not static. There may be a significant nonlinear relationship between them[1-2].

In view of this, this paper collects panel data of 31 provinces, and comprehensively uses linear and nonlinear Granger causality to explore the causal relationship between tourism industrial structure optimization and tourism carbon emissions, in order to provide scientific reference for transforming tourism development mode, promoting low-carbon tourism development and realizing high-quality tourism development.

2 Theoretical Analysis and Research Hypothesis

Optimizing and upgrading the tourism industrial structure is the key way to realize the efficient allocation of tourism resources and promote the development of regional tourism economy. With the continuous development of tourism, it is necessary to strike a balance between supply and demand of products and to ensure coordination between tourism and other sectors. This will lead to the best combination of effective allocation of production factors and social resources. The two main goals of tourism industrial structure optimization are industrial rationalization and upgrading. Rationalization involves coordinating the development of tourism and maximizing the use of resources by adjusting resources between tourism sectors. This leads to an increase in resource utilization and promotes coordinated development between industries. By improving the quality and level of products and services, and promoting the transformation and upgrading of the tourism industry to the direction of

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high added value, high technology content and high efficiency. The upgrading of industrial structure needs to be based on rationalization. The industrial structure has achieved coordinated development at a certain level and then promoted it to a higher level[3-4].

2.1 Impact Mechanism of Tourism Industrial Structure Upgrading on Carbon Emissions

The mechanism of rationalization and upgrading of tourism industrial structure on carbon emission level is different. The rationalization of tourism industrial structure affects the level of carbon emissions through scale effect and structural effect, while the upgrading of industrial structure affects carbon emissions through scale effect, technical effect and market effect, and finally realizes the healthy development of tourism industry.

The scale effect of the rationalization of tourism industrial structure may lead to the trend of carbon emissions increasing first and then decreasing. By accelerating the penetration of innovative tourism production factors between industries and replacing the original industrial capital and labor capital, rationalization drives traditional sightseeing tours to develop in the direction of technological intensification, improves the technological intensity of the whole tourism industry and the linkage between industries, and promotes the formation of emerging tourism industries, thus making resources flow from low-efficiency industries to high-efficiency sectors. Specifically, when the productivity of the tertiary industry exceeds that of the secondary industry, the flow of production factors will occur, thus promoting the expansion of the economic scale. On the whole, the energy input of the tertiary industry is lower than that of the secondary industry, which will lead to the reduction of carbon emissions. Therefore, in the process of rationalization of tourism industrial structure, the expansion of output scale needs more factor input, but the level of resource input and carbon emission is high first and then low[5-6].

The scale effect of tourism industrial structure upgrading will reduce carbon emissions. When the low-tech and low value-added industries in each industry continue to evolve into high-tech and high-value-added industries, this process will bring production factors from low-productivity sectors within the same industry to high-productivity sectors, and attract new production factors. The entry will bring about an expansion of the economic scale, but the main input factors of the tourism industry with high technological content and high added value are technology, information, etc., rather than energy, which will reduce carbon emissions. It can be summarized as follows: The ' structural dividend ' formed in the process of rationalization of industrial structure promotes the development of tourism economy to rely more on technological innovation. Technological progress and technological substitution effect are conducive to promoting CO2 emission reduction. Therefore, there is a negative correlation between industrial structure upgrading and CO2 emissions.

2.2 Impact Mechanism of Carbon Emissions on Upgrading of Tourism Industry Structure

The traditional positioning of tourism as a ' smokeless industry' has been gradually subverted. The rapid development of tourism economy makes the pressure of tourism on the ecological environment increasingly prominent. In recent years, the total amount of carbon emissions from tourism has been rising, up to 4 % to 6 % of the global man-made. If this is not constrained and allowed to develop, carbon emissions from tourism may increase by 1.5 times in the next 30 years. Therefore, promoting tourism carbon emission reduction and promoting the transformation of traditional tourism development model to low-carbon tourism development model is an inevitable measure for tourism to cope with climate change and ecological environment damage. This is also an active choice for modern tourism to promote the upgrading of industrial structure and realize the sustainable development of tourism economy.

Low-carbon economy can promote the development of tourism economy in an orderly manner through various necessary driving forces, economic relations and organizational systems. This economic model focuses on the promotion of low-carbon concepts, technologies and policies, and is committed to developing tourism towards the goal of ' low pollution, low energy consumption, and low emissions '. Specifically, the popularity of low-carbon concept can encourage tourism organizers, participants and managers to change the concept of tourism growth model; the promotion and application of low carbon technology can improve the utilization efficiency of tourism resources and energy, and promote the upgrading of tourism industry structure. In addition, low-carbon policies can also promote the rational use of energy resources and environmental protection through the implementation of protection mechanisms and punishment mechanisms to ensure the sustainability of tourism growth.

Tourism carbon emission is a weak exogenous variable of tourism industrial structure, but tourism carbon emission still has a certain impact on tourism industrial structure. To a certain extent, tourism carbon emissions limit the development of tourism economy and the optimization of tourism structure, reduce carbon emissions, increase the proportion of clean energy and high-tech industries in the tourism industry structure, and make the tourism structure achieve advanced development.

3 Empirical research

3.1 Data selection

This paper seeks to investigate the correlation between China's tourism industry's structural upgrading and rationalization efforts and carbon dioxide emissions in the sector, using data from 2008 to 2019. Linear and nonlinear Granger causality tests were conducted, utilizing various sources of data, such as the "China Tourism Statistical Yearbook," "China Statistical Yearbook," "China Transportation Yearbook," as well as the statistical

yearbooks of provinces and cities, and the patent retrieval system of the State Intellectual Property Office. The study calculates the total tourism income by combining the values of international and domestic tourism income. To calculate carbon dioxide emissions, the paper employs LMDI decomposition technology, which can be found in the "China Tourism CO2 Emission Factor Decomposition" in the "Tourism Science Journal"(Table 1).

3.2 Building first-level indicators

TABLE I. Indicator system

Tourism carbon dioxide emissions	Operating Income of Travel Agencies and Star Hotels	tourism industry structur e upgradi ng
1.Carbon Dioxide Emissions from Tourism Traffic 2.Carbon Dioxide Emissions from Tourism Accommodation 3.CO2 emissions from tourism activities	1.Operating Income of Travel Agencies and Star Hotels 2.Indicates the number of travel agency employees 3.Number of Employees in Star Hotels 4.Total tourism income / tertiary industry income	1.Number of tourism patents 2.International tourism income / total tourism income

3.3 Nonlinear Granger causality test

The linear Granger test effectively explains the linear relationship between variables, while the nonlinear part between variables is ignored. Nonlinear Granger believes that the residual sequence generated in the process of using VAR model in Granger test represents the relationship between the nonlinear part of the explanatory variable and the explanatory variable. Nonlinear Granger test of the residual sequence can find the internal correlation between the neglected parts that cannot be obtained by linear Granger test.

4 Empirical results and explanation

4.1 Unit root test

Before modeling the data, the unit root test is carried out, and the unit root test is carried out on carbon dioxide, rationalization and upgrading of tourism industry. When we test the level value of each time series, it is found that the test statistics of each variable are less than 0.05, indicating that there is no unit root, that is, the data is stable.

4.2 Regression model and Granger causality test

In order to test the research hypothesis of this paper, this paper uses OLS model for regression and Granger model for statistical test. As shown in Table 2, the rationalization of the tourism industry structure in the previous period will lead to a decrease in CO2 emissions in the current period (L. represents the lag operator), and the upgrading of the tourism industry structure in the previous period will also reduce CO2 emissions in the current period. From Table 2, it can be concluded that the Reduction of carbon emissions will promote the development of tourism industry structure in the direction of rationalization and upgrading. Therefore, the linear Granger causality supports the hypothesis that there is a causal relationship between the optimization and rationalization of tourism industrial structure and tourism carbon emissions, and they influence each other.

TABLE II. The traditional Granger causality test between dln Rationalization, dln Advance and CO2

	CO2	Rationalization	Advance
L.Rationalization	-0.198***		-0.155***
	(-7.611)		(-5.826)
L.Advance	-0.814***	-0.698***	
	(-17.067)	(-7.132)	
L.CO2		-0.117	-0.165***
		(-1.512)	(-4.280)
_cons	0.032	0.009	-0.007
	(0.717)	(0.105)	(-0.145)

This paper continues to use the optimal VAR model to estimate the relationship between ' rationalization and upgrading of tourism industrial structure ' and ' carbon dioxide emissions ' to filter out the linear dependence between them. The results are as follows:

TABLE III. Granger causality test based on VAR model

Equation	Excluded	chi2	df	Prob > chi2
CO2	Rationalization	48.142	1.000	0.000
CO2	Advance	170.300	1.000	0.000
CO2	ALL	175.220	2.000	0.000
Rationalization	CO2	4.873	1.000	0.027
Rationalization	Advance	0.413	1.000	0.520
Rationalization	ALL	8.044	2.000	0.018
Advance	CO2	13.366	1.000	0.000
Advance	Rationalization	0.000	1.000	0.984
Advance	ALL	13.701	2.000	0.001

Through table 3, we can know that we rejected the original hypothesis of ' rationalization is not the Granger cause of CO2 ' and ' elevation is not the Granger cause of CO2 ' at a confidence level of 5 %, which indicates that rationalization and elevation are the Granger cause of CO2. The results show that there is a causal relationship between the rationalization and upgrading of tourism industrial structure and tourism CO2 emissions. In addition, we also find that CO2 is also the Granger cause of rationalization and upgrading, which indicates that

reducing CO2 will lead to the rationalization and upgrading of the tourism industrial structure. These results support the hypothesis that the upgrading of tourism industrial structure is related to carbon dioxide emissions.

4.3 Nonlinear Granger test

In order to ensure the reliability of the results, this paper uses the nonparametric Tn test method proposed by Diks and Pan-chenko (2006) to perform nonlinear Granger test on the data. The selected nonparametric detection bandwidth is 1. The results are as follows (fig 1):

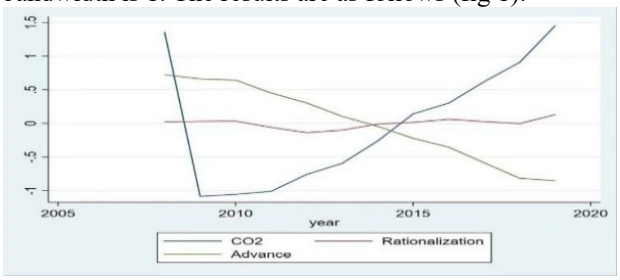

Fig. 1. Nonlinear Granger test

According to the results of nonlinear Granger causality test, the original hypothesis is that there is no nonlinear Granger causality between ' rationalization of tourism industry ' and ' carbon emission ', and there is no nonlinear Granger causality between ' advanced tourism industry ' and ' carbon emission '. Considering the common lag order of 1 ~ 5, the p values of the test are less than 5 %. This shows that there is a nonlinear Granger causality between ' rationalization of tourism industry ' and ' advanced tourism industry ' and ' carbon emissions '. This conclusion once again confirms the research results of this paper. It is worth noting that when the common lag order is 1, we find that there is a nonlinear Granger causality between ' carbon emissions ' and ' tourism industry rationalization '. When the common lag order is 1 and 2, we also observe that ' carbon emission ' shows a leading nonlinear Granger causality to ' rationalization of tourism industry '.

5 Conclusion

In this paper, the nonlinear Granger causality test method is used to analyze the nonlinear causality between ' tourism industrial structure upgrading ' and ' tourism carbon dioxide ' in 31 provinces of China. In the process of research, the use of non-parametric test method effectively overcomes the deviation of the conclusion caused by ignoring the nonlinear relationship between variables, thus overcoming the limitations of the traditional Granger causality test method to a large extent, and thus enhancing the reliability and rationality of the conclusion of this paper.

At the same time, this paper combines nonlinear dynamic analysis to carry out further in-depth research. The analysis shows that with the continuous acceleration of the upgrading and rationalization of the tourism industrial structure, the optimization and adjustment of the structure reduces the level of carbon dioxide emissions, so that the nonlinear relationship from ' economic growth ' to ' economic growth ' is gradually approaching the significant interval.

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