Estimation of Carbon Emissions from Changsha Tourism and Analysis of Influencing Factors

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Abstract. Based on the data of Changsha City from 2002 to 2019, this paper applies the carbon footprint method to six aspects of tourism transportation, tourism accommodation, tourism catering, etc., and finally sums them up to get the total carbon emission valuation, and then analyzes the influencing factors affecting the carbon emission of the tourism industry in Changsha City using the STIRPAI model. The results show that: the carbon emissions of Changsha's tourism industry have been increasing year by year, among which the carbon emissions of tourism transportation account for the highest proportion; Of all the influencing factors, tourist size has the greatest impact.

Keywords: tourism; carbon emissions; influencing factors.

1 Introduction

Nowadays, the development of tourism is in full swing, and has led to the development of the economy through a variety of ways[1] . Research predicts that tourism could overtake most sectors of the economy as a major contributor to global carbon emissions in the future[2] .The large-scale international and domestic tourists as well as the wide range of elements of tourism activities have brought about carbon emissions that should not be underestimated, and the carbon emissions of China's tourism industry accounted for 11.8% of the country's carbon emissions in 2019, which is a very high percentage. Nowadays, the world is paying more and more attention to ecological construction, China, as a big country with responsibility, has also taken the corresponding responsibility, in September 2020, President Xi Jinping put forward the "dual-carbon" goal. The "dual-carbon" goal is a major strategic decision deployed by the CPC Central Committee, and is a key direction for the high- quality development of China's economy and a major component of the construction of an ecological civilization.

In recent years, with the rapid development of the Internet, as well as the formation of scenario-based communication with short videos, a number of "Netroots Cities" have been born, which is a topic that cannot be avoided when talking about the tourism industry. In this context, this paper takes Changsha, a prefecture-level city, as the research object, reasonably estimates its carbon emissions and analyzes the factors

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affecting carbon emissions, and finally gives carbon emission reduction suggestions, which are of certain theoretical and practical significance for the sustainable development of Changsha and even the tourism industry, as well as for the planning and design of tourism.

Regarding the research on carbon footprint of tourism, scholars at home and abroad mainly gather at the global, national and provincial scales, and for the time being, the research at the macro level is more in favor of the macro level, and the research at the micro-regional level is less. As far as foreign countries are concerned, the current research mainly focuses on the measurement methods, influencing factors, sources of tourism carbon footprint, and the carbon footprint of specific industrial sectors in tourism [3]. In terms of foreign countries, the current research mainly focuses on the measurement methods, influencing factors, sources of tourism carbon footprint, and carbon footprint of specific industry sectors in tourism. Domestic scholars mainly focus on the measurement of different scales of carbon footprint, analyzing the structure of the carbon footprint of tourism, and suggesting paths to reducethe carbon footprint [4].The main focus of domestic scholarsison the measurement of carbon footprint at different scales, analyzing the structure of tourism carbon footprint and suggesting paths to reduce it [5].

In terms of the factors affecting carbon emissions from tourism, the most used model is STIRPAT, which was first created by Ehrlich and Holdren as the IPAT equation to study the impact of demographic factors on the environment [6]. It was first created by Ehrlich and Holdren as the IPAT equation to study the impact of population factors on the environment. Leontief and Ford firstly proposed the SDA method to solve the environmental problems, and used it to measure the influence of various factors on the environment [7]. The SDA approach was first proposed by Leontief and Ford to solve environmental problems and used to measure the impact of various factors on the environment. After that, the extended model began to be commonly used, and Guo Motion et al. applied the STIRPAT extended model to study the influencing factors of Shanghai's carbon emissions[8].Liu Xiaoyan Liu Xiaoyan applied the STIRPAT model to the study of the factors affecting industrial carbon emissions in China, specifically studying the factors affecting the intensity and scale of carbon emissions[9]. Lin used LMDI method to decompose the factors affecting carbon dioxide emissions, and the results show that energy intensity and per capita income have an impact on it[10].

To summarize, the research of carbon footprint and STIRPAT methods is relatively mature, but few of them put the perspective on the municipal level, so this paper takes Changsha City as an example to study in depth the factors affecting its carbon emissions and give reasonable emission reduction suggestions in combination with the dual-carbon target.

2 Research Methodology

2.1 Estimation of Carbon Emissions

Tourism involves six aspects: catering, accommodation, transportation, excursions, shopping and entertainment. Since the carbon intensity and carbon per unit of energy consumption of different industries are different, the carbon emissions of these six industries can be calculated separately and then summed up with the formula:

$$TCF = CF\text{c} + CF\text{a} + CF\text{t} + CF\text{v} + CF\text{s} + CF\text{r} \quad (1)$$

In Eq. (1), CF c, CF a, CF t, CF v, CF s, CF r denote the carbon footprint of tourism food and beverage, tourism accommodation, tourism transportation, tourism excursion, tourism shopping and tourism entertainment, respectively. Referring to the research results, the tourism carbon footprint industry model can be expressed as follows:

$$TCF = \sum_{i=1}^{6} D_i P_i K_i \quad (2)$$

In Eq. (2): Di is the regional tourism revenue, Pi is the energy intensity of the industry, and Ki is the carbon emission factor of the industry.

3 Analysis of Factors Affecting Carbon Emissions

After analyzing the results of previous scholars' research and the actual situation in Changsha City, and initially screening the influencing factors of tourism carbon emission, we constructed the STIRPAT extended model to quantitatively screen the influencing factors of tourism carbon emission in Changsha City. Relevant scholars extended the STIRPAT model to obtain the following model:

$$I = \alpha {X_1}^{\beta_1} {X_2}^{\beta_2} \cdots {X_n}^{\beta_n} \varepsilon \quad (3)$$

Where: I refer the environmental conditions, and this paper refers to the carbon emissions of tourism; Xi denotes a set of explanatory variables affecting the carbon emissions of tourism, involving the urbanization rate (V), industrial structure (U), technological level (T), the size of tourists (P), per capita tourism income (A), and the level of economic development (S); α and β i are the parameters of the model, and ε is the model's random error term. In order to eliminate the multicollinearity between the explanatory variables, equation (1) is treated logarithmically here and becomes:

$$\ln I = \ln \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 \cdots \beta_n \ln X_n \quad (4)$$

3.1 Data Sources

In this paper, Changsha City is selected as the research object, due to the need to analyze the data by regression processing and the influence of the epidemic, the data from 02-19 are selected for the study. All data are from Changsha City Statistical Yearbook, Hunan Province Statistical Yearbook, China Energy Statistical Yearbook, China Tourism Sample Survey Data, etc. Due to the missing of individual data, the article uniformly used the linear interpolation method to supplement the processing.

4 Empirical Analysis

4.1 Estimation of Carbon Emissions from Tourism in Changsha

Based on the data from 02-19, the carbon emission situation of Changsha City in these years was calculated using equations (1) and (2).The carbon emissions from the tourism industry in Changsha City have been increasing year by year, and compared with others, the carbon emissions from tourism transportation account for the highest proportion of the total emissions, accounting for 62%, which shows that tourism transportation is the main source of carbon emissions from the tourism industry, and that the promotion of carbon emission reduction in the tourism industry can be focused on starting from the tourism transportation. The part situation in recent years is shown in Table 1:

Table 1. part carbon emissions

year	Transportation/t^3	Lodging/t^3	Gastronomy/t^3	Diversion/t^3	All/t^3
2015	10208.52	784.35	547.80	423.30	16367.24
2016	11593.07	890.73	622.10	480.71	18587.08
2017	12538.01	963.33	672.80	519.89	20102.09
2018	13656.68	1049.28	732.83	566.28	21895.65
2019	15326.00	1177.54	822.41	635.50	24572.05

4.2 Analysis Of Influencing Factors of Tourism Carbon Emission in Changsha

Changsha City's tourism carbon emissions show a year-on-year growth trend, so it is very necessary to analyze the driving factors behind its carbon emissions in depth. After understanding the basic situation of Changsha City and analyzing the data from previous years, six factors such as urbanization rate, industrial structure, and technological level were finally selected for analysis, and the expanded STIRPAT model was applied to further determine the degree of influence of each factor. The following is the analysis section:

The variables V, U, T, P, A, and S were first deal with using Stata to obtain lnV, lnU, lnT, lnP, lnA, and lnS. After that, their covariance was tested by variance inflation factor, and it was found that the VIF values were all much larger than 10. The above results indicate that there is a very serious covariance between the variables and the least squares method cannot be used directly to elaborate the factors affecting carbon emissions. Immediately after that, the ridge regression method was used for fitting, so that the results obtained are also more in line with the reality. After that, the above explanatory variables were fitted to the regression by SPSS software, resulting in the K value in the regression of Changsha City data with the corresponding R2 and the ridge trace plot, as shown in Figure 1 below:

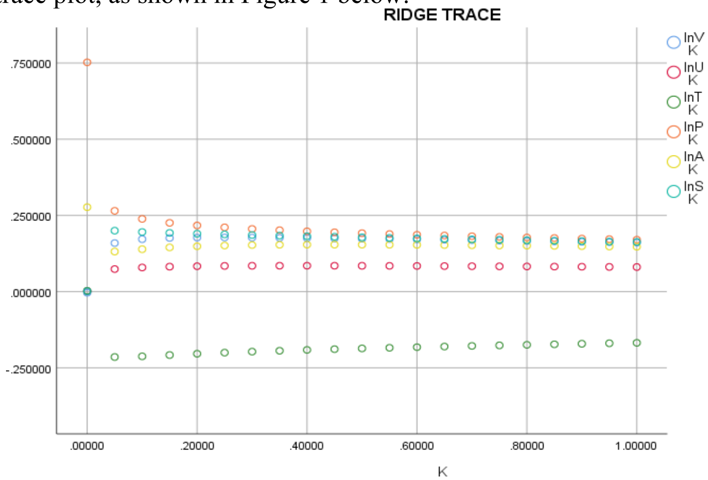

Fig. 1. Map of the ridge regression ridge trace

As can be seen from Figure 1, the ridge regression coefficient basically tends to stabilize when the K value is between 0.2 and 0.3. Therefore, the K value should be selected in this range, and when K=0.2, the corresponding R2 is more close to 1, 0.9931, which is the best simulation effect, indicating that each variable is able to explain the carbon emissions to the extent of 99%. The fit for the selected K=0.2 is shown in Table 2:

Table 2. The fit for K=0.2

Mult R .9965810753		RSquare.993173		
Adj RSquare .97952		SE .8028780050		
	B	SE(B)	Beta	B/SE(B)
lnV	.16737692	.01419632	.16523618	11.79016319
lnU	.15713535	.01368988	.15651987	11.47821649
lnT	.07258638	.03780277	.07609817	1.92013388
lnP	.23395431	.03254149	.24245805	7.18941599
lnA	.20921181	.02134819	.21174659	9.79997681
lnS	.12330689	.02849337	.12089743	4.32756374

As shown by the data as above, the optimization of the regression equation obtained at this point, is:

$$\ln I = 0.393 + 0.167 \ln V + 0.157 \ln U + 0.073 \ln T + 0.234 \ln P + 0.209 \ln A + 0.123 \ln S$$

5 Conclusions

From the equation, the coefficients before each variable are positive. Among them, the coefficient of tourists' scale is the largest and has the highest impact on carbon emissions, which is because with the improvement of material living standards, people's pursuit of spirituality is also improved accordingly, and more and more people choose to go on a tour, especially during holidays, the impact of the flow of people on the scenic spots is especially obvious. This is followed by the per capita consumption level, urbanization rate and industrial structure, which also reminds us to focus on the impact of demographic factors and industrial layout on carbon emissions in terms of carbon reduction.

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