

Estimating the influence of tourism and economic growth on carbon emissions: the case of China.

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Abstract. This paper selected provincial data from 2005 to 2015 to study the relationship between China's tourism development and carbon emissions. The results show that there is a significant positive correlation between economic growth and carbon emissions, but there is a negative correlation between tourism development and carbon emissions. Among them, the negative correlation between domestic tourism and carbon emissions is more significant than that between international tourism, and there is a significant positive correlation between fixed asset investment and carbon emissions. Based on the above conclusions, suggestions for relevant policies are put forward as follows. The government should formulate environmental protection policies while developing the economy. At the same time, we should develop tourism, especially domestic tourism to reduce environmental pollution, and resolutely put an end to the investment and introduction of the industries with high consumption and high pollution, always adhering to green, low carbon and sustainable development.

1. Introduction

Since the reform and opening up, China's economy is in a stage of rapid development and gradual transformation to high-quality development. The interaction between the economic take-off and the unbalanced development leads to low utilization of natural resources and huge energy consumption. The problem of high concentration and high intensity carbon emission becomes more and more serious with the increase of energy consumption. According to the statistics of China carbon trading network, China's annual carbon emissions are about 103.57 million tons, who has already become the world's second largest carbon emission country (Liu Yanhua, 2008). The increase of carbon emissions has led to increasingly serious environmental problems in China. China's carbon emissions have already exceeded the affordability of ecosystem, which has also caused a series of impacts on the global climate. However, the development of tourism also depends on the natural resource and ecological environment, and the rapid development of tourism economy is closely related to environmental protection. Studies have shown that tourism is responsible for 4.4% of global carbon emissions, and this effect is expected to increase at an average annual rate of 3.2% over the 30-year period of 2005-2035 (Peeters, 2010). At present, China is in the period of comprehensive development of tourism, and carbon emissions from tourism transportation, tourism accommodation and other tourism sectors also gradually increase, causing irreversible harm to the environment (Md. Samsul Alam, 2017). Tourism activities also have a certain impact on greenhouse gas emissions (Stefan, 2002). Therefore, while developing tourism, it is also extremely urgent to formulate scientific planning programs for environmental protection, and it is of great significance to study the relationship between tourism development and environmental pollution. By studying the relationship between tourism development and carbon emissions, this paper aims to provide a reference for the scientific development of tourism economy and sustainable development of tourism.

2. Literature Review

Compared with foreign countries, domestic studies on tourism and carbon emissions are relatively lagging behind, and only after 2009 did the research gradually increase, and the research mainly focused on the relevant categories of low-carbon tourism and sustainable tourism. Since 2012, studies on the closer connection between tourism and carbon emissions have gradually emerged, mainly focusing on carbon emission measurement of tourism, carbon footprint measurement of tourism and the impact of tourism carbon emissions and relevant countermeasures.

Relatively speaking, the research on carbon emission measurement of tourism takes up the largest proportion in the research on the relationship between tourism and carbon emission, which is mainly divided into two aspects. One aspect is the carbon emission measurement of regional tourism. Among them, the "bottom-up" approach and the "top-down" approach are the most basic methods to study the carbon emission of regional tourism. The "bottom-up" approach mainly starts with the tourism industry and tourists, and measures the information related to the use of energy terminals and the main influencing factors of carbon emissions. Using the "bottom-up" approach to quantitatively estimate the carbon emissions of tourism in Shandong Province of China, the carbon emission of tourism in Shandong can be divided into three categories: high, medium and low carbon emission regions. Carbon emissions of tourism in Shandong are generally high in the east and low in the west, and high in the north and low in the south. Per capita carbon emissions of tourists and carbon emission intensity of tourism are decreasing year by year (Tian Hong & Ding Chang'an, 2018). Based on the "bottom-up" approach, the total carbon emission of tourism in the Yangtze River delta region continues to rise, and is positively correlated with the total revenue of tourism (Xie Yuanfang & Zhao Yuan, 2012). In addition, Zhejiang province has the largest carbon emission from tourism, while Shanghai has the least (Tao Yuguo & Huang Zhenfang, 2013). The "top-down" approach evaluates tourism as an economic sector, comparing it with the ecological benefits of other industries or the impact of macroeconomic tools such as carbon taxes. Using the "bottom-up" and "top-down" approaches to calculate the tourism carbon footprint of New Zealand, it is found that the two methods have similar estimates of energy consumption and emissions. (Patterson, 2006). In addition to the carbon emission measurement of regional tourism, researches on the carbon emission measurement of tourism prefer to conduct the carbon emission measurement according to four sectors of tourism, namely tourism transportation, tourism accommodation, tourism activities and tourism food. Among them, the tourism and transportation sector has been studied the most. According to the proportion of tourists in the passenger traffic volume, the carbon emission of tourism transportation is preliminarily estimated, and the carbon emission is linearly correlated with the number of tourists. The carbon emissions of China's railway, highway, civil aviation and other tourism transportation increases, while the water transportation decreases (Wei Yanxu & Sun Gennian, 2012). As for the measurement of tourism carbon footprint, the total tourism carbon footprint of Barcelona is about 9.6 MtCO₂eq/year, and the per capita carbon footprint is about 96.9Kg/ day. The main source of carbon emission is still tourism transportation (Anna, 2018). The total carbon footprint of China's tourism in 2012 was about 33.4 10⁹ kg, accounting for 0.387% of the total carbon footprint, far below the international average (Du Peng & Yang lei, 2016). Based on the accounting of tourism carbon emission and tourism carbon footprint, some literatures further analyzed the influencing factors of tourism carbon emission, among which, tourism transportation is the main driver of carbon emission of tourism in all the provinces. Factors such as economic growth, service industry development, opening extent, location condition and urbanization have a significant positive influence on carbon emission intensity of tourism (Zha Jianping & Shu Haoyu, 2017). However, in some other literatures more in-depth researches are conducted based on tourism carbon emissions data from the perspective of regional space or time. The total carbon emission of tourism is on the rise year by year, and the growth rate of central and western regions is significantly higher than that of eastern regions. However, the carbon emission intensity of tourism is decreasing year by year, and the decline rate in central and western regions is significantly lower than that in eastern regions (Pan Zhiqiang & Liang Bao'er, 2016).

To sum up, the research on carbon emission of tourism is mainly limited to three aspects: one is to measure tourism carbon emissions, tourism carbon footprint and tourism carbon intensity based on regions and tourism sectors; another is to explore the influencing factors and countermeasures of tourism carbon emissions; and the third is to analyze the differences of tourism carbon emissions from the perspective of time and space.

There are more literatures directly studying the relationship between tourism and carbon emissions abroad than in China, and it is often related to the environmental Kuznets curve. On the basis of the environmental Kuznets curve hypothesis, some academic studies have explored the relationship between tourism development, energy consumption and carbon emissions in developed and developing countries, finding that tourism development can promote the increase of carbon emissions, which will bring environmental pollution (Khalid & Muhammad, 2016). However, in different regions, the results are different. For example, in Europe, energy consumption can increase carbon emissions, but tourism development and actual income are negatively correlated with carbon emissions (Eyup & Alper, 2017). In Cyprus, tourism development is the catalyst of energy consumption and carbon emission growth (Salih, 2014). In Malaysia, tourism development is positively correlated with carbon emissions, while in Singapore and Thailand it is the opposite (Muhammad, 2018). However, there are very few academic articles studying the relationship between tourism and carbon emission in China, no more than 10 literatures. Among them, there is three studying tourism consumption, tourism economic growth, and the relationship between tourism development and carbon emission, respectively. The per capita consumption of inbound tourism in China is significantly correlated with the carbon emission of the tertiary industry. With the per capita consumption of inbound tourism increasing, the impact on carbon emission increases slowly at first and then accelerates (Dong Hongmei & Zhao Jingbo, 2010). In addition, the relationship between China's tourism economic growth and carbon emissions remained relatively decoupled in all the years except 2003. There is a long-term co-integration relationship between tourism economic growth and carbon emissions (Wang Kai & Li Juan, 2014). Based on the environmental Kuznets curve, the influence of China's tourism development of regional carbon emissions were discussed and it was found that the inverted "U" EKC hypothesis between traditional economic growth and carbon emissions was valid, tourism development had a significant impact on regional carbon emissions, the fitting curve of tourist receptions and per capita carbon emissions showed a positive "U" shape, and per capita tourism consumption and per capita carbon emissions showed a typical inverted "U" curve of benign development (Wang Kai & Shao Haiqin, 2018). On the basis of previous studies, this paper attempts to use 29 provinces and cities as the research objects, calculate the carbon emissions of each province and analyze the relationship between tourism development and carbon emissions, so as to enrich the research in this field.

3. Data and models

3.1 Research samples and data sources

According to the availability of data in the national bureau of statistics database, data of relevant variables for carbon emission calculation were selected from *China Statistical Yearbook*, *Provincial Statistical Yearbook*, *Carbon Emission Trading Network* and *Compilation of 60 Years' Data of New China*. Economic data and tourism development data were obtained from *China Statistical Yearbook*, *Provincial Statistical Yearbook*, *China Regional Economic Statistical Yearbook* and *China Tourism Statistical Yearbook*. At the same time, the provinces with missing data sources were excluded, and the research interval was finally determined as the sample data of 29 provinces and cities in China over the 10-year period from 2005 to 2015.

3.2 Model setting and variable definition

On the basis of previous studies, this paper took per capita carbon emission as the explained variable, took tourism development and economic growth as the core explained variable. Meanwhile, in order to avoid the possible strong correlation between the core explained variable

and random perturbation term in the model, this study also incorporated relevant variables such as technological development and educational investment that reflect regional characteristics into the empirical model. The model was built as follows:

$$CO_2 = \beta_0 + \beta_1 GDP_{i,t} + \beta_2 tourism_{i,t} + \sum_i \alpha control + \varepsilon \quad (1)$$

Where, CO_2 is the explained variable, representing per capita carbon emissions; *tourism* is one of the core explanatory variables, representing tourism development in each province; *GDP* is also another core explanatory variable, representing economic growth of each province. The subscript i,t denotes province and year; *control* is a series of control variables, ε is the residual term. In this study, the panel regression model is adopted to construct the balanced panel data of 29 provinces and cities in China from 2005 to 2015. The samples are widely representative, which is helpful to draw a relatively scientific conclusion. Grossman (1991) et al. proposed the environmental Kuznets curve on the basis of the Kuznets curve, that is, the inverted “*U-shaped*” relationship between economic growth and environmental quality. This paper referred to the research of Khalid (2016) et al. on the relationship between energy consumption, tourism development and environmental quality, and finally determined the model as:

$$CO_2 = \beta_0 + \beta_1 GDP_{i,t} + \beta_2 GDP_{i,t}^2 + \beta_3 tourism_{i,t} + \beta_4 rpe_{i,t} + \beta_5 rpfa_{i,t} + \varepsilon \quad (2)$$

The variables used in the empirical analysis of this paper are divided into three categories: first, per capita carbon emission (CO_2) is taken as the explained variable, and the data comes from China's carbon emission database (CEADs). This paper used the method (1) of the *Urban Energy Consumption Carbon Emissions Accounting Methods*. First, based on the energy balance sheet in the *national statistical yearbook*, the structure chart of energy consumption process is established from the perspectives of energy input, processing transformation and final consumption. Next, the generation process of carbon emissions in energy consumption was distinguished, and the energy that is included in the calculation of carbon emissions was determined. Then the types of energy in the energy balance sheet were divided according to the default carbon content coefficient of energy in the *IPCC* list. Finally, the energy consumption of each included in the calculation was multiplied by the corresponding carbon emission factor of the energy type. Therefore, the missing provinces were identified to calculate the carbon emissions of 29 Chinese provinces and cities. As for the core explanatory variables of this paper, the tourism development (*tourism*) is measured by the total number of tourists, while the economic growth (*GDP*) is measured by per capita *GDP*. Among other control variables, education investment (*rpe*) is measured by per capita educational expenditure index of each region, while technological development (*rpfa*) is measured by per capita fixed asset investment.

3.3 Statistical description of variables

The descriptive statistical results of samples are shown in Table 1 below.

Table 1: descriptive statistics of each variable

Variable	Max	Min	Mean	Std. Dev.
CO_2	842.2	16.5	272.5884	184.1335
<i>GDP</i>	107960.1	5051.96	35171.24	21917.06
<i>tourism(T)</i>	654000000	4018200	176000000	142000000
<i>TT</i>	650.45	4.0082	173.172	140.9207
<i>IT</i>	34.89	0.01	2.877241	5.338029
<i>rpe</i>	5037.943	306.2096	1345.235	800.9451
<i>rpfa</i>	7.648	0.268	2.25573	1.425317

From the perspective of the explained variables, the average carbon emissions in each province were 184.13. Carbon emissions were unevenly distributed among different years and provinces.

From the perspective of explanatory variables, per capita *GDP* (*GDP*) represents economic growth of each province from 2005 to 2015, with an average value of 5,051.96. The total number of tourists (*tourism*) represents tourism development in various provinces and cities from 2005 to 2015, with an average value of 176,000,000, of which the maximum value is 654,000,000 and the minimum value is 4018200. There is a big gap between the two, which reflects the different tourism development in different provinces and cities. The maximum value of the total number of domestic tourists (*TT*) is 650.45 and the minimum value is 4.0082, while the maximum value of the total number of international tourists (*IT*) is 34.89 and the minimum value is 0.01, both of which are significantly lower than domestic tourists.

4. Literature references

This paper examines the impact of China's tourism development from 2005 to 2015 on per capita carbon emissions in each province. Firstly, the energy balance table is used to establish the flow chart of energy consumption. According to the carbon emission process in the flow chart, the energy consumption is calculated, and the double-counted energy consumption is eliminated. Finally, the per capita carbon emission of each province is calculated by the product of carbon emission factors of different energy types and energy consumption. On the basis of carbon emissions, the impact of tourism development on per capita carbon emissions was judged, with more in-depth study of the number of domestic tourists and the number of foreign tourists on per capita carbon emissions later.

4.1 Quantitative inspection on the impact of tourism development on carbon emissions

On the basis of the per capita carbon emission of each region, the panel data model is used for the regression analysis of the sample data. There are three different regression models for panel data model, including fixed-effect model, random-effect model and OLS mixed model. The most suitable regression model can be obtained through *Wald* test, *B-P* test and *Hausman* test. The test results of the impact of tourism development on per capita carbon emissions are shown in table 2:

Table 2: Quantitative inspection on the impact of tourism development on carbon emissions

Method of estimation		(1)	(2)	(3)
		OLS	FE	RE
Explanatory variable	<i>GDP</i>	2.709** (1.311)	0.677** (0.304)	0.670** (0.332)
	<i>GDP</i> ²	-0.101 (0.062)	-0.014 (0.014)	-0.016 (0.015)
	<i>T</i>	0.434*** (0.030)	-0.176*** (0.034)	-0.092*** (0.035)
Controlled variable	<i>rpfa</i>	0.444*** (0.098)	0.184*** (0.044)	0.170*** (0.048)
	<i>rpe</i>	-1.251*** (0.114)	0.031 (0.045)	-0.001 (0.049)
Constant term	cons	-5.248	0.423	0.537
Observed value	N	319	319	319
<i>Wald</i> test		303.64	Fixed-effect model is superior to mixed regression model	
<i>B-P</i> test		1072.21	Random-effect model is better than mixed regression model	
<i>Hausman</i> test		-110.05	Fixed-effect model is better than random-effect model	

Note: the coefficient in brackets is the standard error; ***, ** and * respectively indicate that the estimated values of parameters are significant at the statistical level of 1%, 5% and 10%.

Wald test showed that FE was superior to mixed OLS. According to *B-P* test, RE is superior to mixed OLS. Finally, when comparing FE and RE, first assuming that RE is superior to FE. *Hausman* test results reject the original hypothesis, and the basic hypothesis of RE cannot be satisfied. In conclusion, compared with mixed regression model and random-effect model,

fixed-effect model is more convincing. In the fixed-effect model test results, the p value is close to 0 and rejects the null hypothesis, indicating that per capita GDP is significantly related to per capita carbon emissions. After adjustment, the goodness of fit value is 0.854, which indicates the following. (1) The fitting degree of the model is good, and per capita GDP is linearly correlated with per capita carbon emissions. The regression results of per capita GDP and carbon emissions are significant at the level of 5%, that is, per capita GDP and per capita carbon emissions show a significant positive correlation, indicating that the higher the economic growth, the greater the per capita carbon emissions. (2) The regression results of the total number of tourists and per capita carbon emissions are significant at the level of 1%. The total number of tourists and per capita carbon emissions show a significant negative correlation, which also indicates that the higher tourism development, the less per capita carbon emissions. (3) Per capita fixed asset investment and per capita carbon emissions are also positively correlated under the level of 1%, indicating that the higher the technological investment in each region, the greater the per capita carbon emissions.

4.2 Quantitative inspection on the impact of tourism development structures on carbon emissions

In order to further explore the relationship between tourism development and per capita carbon emissions, this paper will decompose the factors affecting tourism development and use domestic tourists and international tourists as the explanatory variables instead of the total number of tourists to conduct panel data regression to further explore the relationship between tourism and carbon emissions. The regression results are shown in the following figure.

Table 3: quantitative inspection of the impact of tourism development structures on carbon emissions

Variable	CO_2		
GDP	0.677** (0.304)	0.703** (0.304)	0.655** (0.316)
GDP^2	-0.014 (0.014)	-0.016 (0.014)	-0.019 (0.014)
T	-0.176*** (0.034)		
TT		-0.177*** (0.034)	
IT			-0.062** (0.027)
$rpfa$	0.184*** (0.044)	0.185*** (0.045)	0.170*** (0.048)
rpe	0.031 (0.045)	0.030 (0.045)	0.037 (0.046)
_cons	0.423	2.760	0.216
N	319	319	319
R^2	0.854	0.854	0.843

Note: the coefficient in brackets is the standard error;***, ** and * respectively indicate that the estimated values of parameters are significant at the statistical level of 1%, 5% and 10%.

The regression equation coefficient table of panel data obtained from table 3 shows the correlation between tourism development and carbon emissions. The fixed-effect model was used to investigate the relationship between the per capita carbon emissions and the number of domestic tourists, and the number of international tourists, respectively. By comparison, the followings can be observed. (1) The P value of domestic tourists is close to 0, indicating that there is a certain linear correlation between the number of domestic tourists and per capita carbon emissions, and the adjusted P value is 0.854, indicating that the curve fitting is good. At the 1% level, domestic tourism and carbon emissions showed a significant negative correlation. (2) The P value of international tourists tends to 0, indicating that there is a linear correlation between the number of international tourists and per capita carbon emissions, and the adjusted P value is 0.843, indicating that the curve fitting is good. Under the 5% level, international tourism and carbon emissions show a significant negative correlation. (3) The relationship between the number of domestic tourists and

per capita carbon emissions is significant at the level of 1%, which is significantly better than that between the number of international tourists and per capita carbon emissions, indicating that the impact of domestic tourism and carbon emissions is closer.

5. Conclusions

Base on the data in 29 provinces and cities in the country from 2005 to 2015, this paper examines the impact of tourism development and economic growth on per capita carbon emission by taking the per capita carbon emission as the explained variable, the per capita GDP and total number of tourists as the explanatory variables, and the per capita education expenditure, per capita fixed asset investment as controlled variables. And the conclusions are as below:

Carbon dioxide emissions increase with the increase of per capita GDP, which reveals that the economic growth is significantly positively correlated with carbon emissions. Therefore, when increasing GDP, China should also face up to the damage brought by economic development to the environment. The use of clean energy and the development of low-carbon economy are important ways to solve the environmental pollution caused by economic development.

There was a significant negative correlation between tourist receptions and carbon emissions, that is, carbon dioxide emissions decreased with the increase of tourist arrivals, indicating that the development of tourism plays a certain role in energy conservation and emission reduction. In addition, the domestic tourist reception and the international tourist reception are also negatively correlated with the per capita carbon emissions, but the negative correlation between the domestic tourists and the per capita carbon emissions is more significant than the international tourists. This result demonstrates that vigorously developing tourism, especially domestic tourism, will effectively improve the environmental quality. Most areas of China's tourism development attach great importance to the development and utilization of forest and beach resources. Especially in recent years, in order to achieve sustainable utilization, the economic focus has shifted to industries with low energy consumption and low emissions, thus reducing carbon emissions. Therefore, China should vigorously develop tourism, promote the use of tourism transportation, tourism accommodation and other industries, promote sustainable development, and reduce carbon emissions.

At the same time, the research results illustrate that there is a positive correlation between the technological investment and carbon emissions, indicating that some industries with high investment have caused certain harm to China's environment. A series of investment-oriented policies should be formulated to limit the development of some industries that pollute nature reserves and the ecological environment of plants and animals. At the same time, the government should also pay more attention to the introduction of foreign investment, putting an end to the projects with high consumption and high pollution, and selecting the projecting in line with the local resources. On the other hand, the government should stick to the idea of "green and low-carbon" development in the urbanization plan.

With the growth of social economy and the improvement of investment, carbon emissions will increase to a certain extent. By studying the relationship between economic growth, tourism development, technological investment, education development and environmental quality, this paper aims to provide the most effective solutions to environmental pollution. Firstly, the government should issue some policies to develop low-carbon economy in accordance with the current economic form of social development. Meanwhile, the government should use clean energy and other tertiary industries to assist the development of other industries. Secondly, the government should vigorously promote the development of tourism, especially the development of domestic tourism, and promote the utilization of sustainable resources, which will protect the environment. Moreover, targeted intervention policies should be formulated for industries with greater environmental damage to reduce the introduction of polluting industries.

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