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The Impact of Tourism on Carbon Emissions in China

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Abstract: This paper constructs the index system of tourism and studies the relationship between tourism and carbon emissions with panel data of 30 provinces during 2001-2015. The Generalized Spatial Two-stage Least Square (GS2SLS) model is used to solve the potential endogenous problems and identify the spatial spillover effects. The key findings show that: China's carbon pollution has a significant spatial spillover effect; the principle of joint defense should be followed to maximize the environmental benefits. There is a U-shaped relationship between tourism and carbon emission. More attentions are needed on the low-carbon development of tourism. Digitization can reduce the positive effect of tourism on carbon emissions. It is necessary to make the digital transition.

Keywords: Tourism; Carbon Emissions; GS2SLS; Digitization.

1. Introduction

As the world's largest industry, tourism has a great potential in affecting carbon emissions. China hosted 6.01 trillion domestic tourists and 145 million international tourists in 2019. The contributions of tourism are 10.94 trillion, accounting for 11.05% of GDP and reaching the average level of the world. However, great economic effects are accompanied by high levels of carbon emissions (Bekun et al., 2019; Ghosh, 2021). It is shown that China ranked second (after the United States) for its carbon footprint of tourism. And the carbon emissions caused by tourism further increase at 10% a year (Lenzen, et al., 2018). It is essential to explore the impacts of tourism on carbon emissions for understanding the environmental effects of tourism and studying sustainable pathways of tourism sector in China.

With the expansion of tourism, a growing concern is emerging as to the roles of tourism in carbon reduction and emissions peak (Lee et al., 2021). However, the research conclusions of relevant studies are controversial (Yue et al., 2021).There are short-term and long-term impacts of tourism on carbon emissions (Lee and Brahmasrene, 2016; Yiidirim et al., 2021). And the relationship between tourism and carbon emissions is non-linear (Kocak et al., 2020; Yiidirim et al., 2021;Raza et al., 2021).

Beside the industrial dimension(scale, stage, etc.) of tourism above, the spatial dimension is also important for the relationship between tourism and carbon emissions (Li and Lv, 2021). It is shown that the development of tourism leads to the spatial expansion and agglomeration in destination (Huang et al., 2021). And both kind of development in spatial dimension require more investment in tourism infrastructure, such as transportation, digital technologies for smart tourism, catering, accommodations and water supply, etc., which further affects carbon emissions (Li and Lv, 2021; Ma et al., 2021; Romao and Neuts, 2017). Moreover, the per capita income (Akadiri et al., 2021; Katircioglu, 2014; Le and Nguyen, 2021), energy intensity (Chen et al., 2018b; Kocak et al., 2020), energy structure (Balsalobre-Lorente et al., 2021; Tang et al., 2017; Zha et al., 2020), urbanization (Pan et al., 2021; Wu et al., 2020), industrial structure (Tang et al., 2017), globalization (Akadiri et al., 2021; Balsalobre-Lorente et al., 2020), etc., are also shown as the key factors affecting the relationship between tourism and carbon emissions.

The diversity of empirical findings indicates that impacts of tourism on carbon emissions are not limited to single dimension of tourism (Kocak et al., 2020). Multiple dimensions indicator of tourism should be used to ensure the reliability of the empirical conclusions (Huang et al., 2021). In addition to the two dimensions above, the industrial linkage driven by tourism should be included in the environmental effects of tourism. It is shown the total output reduces 6% if the tourism industry is extracted from the whole economy (Zuo and Yang, 2021). The "losing" outputs are closely related with tourism, which also make a contribution to the carbon reduction or carbon emissions. Secondly, the bidirectional causality between tourism and carbon emissions affects the empirical results above (Zhang and Zhang, 2020). The econometric model without discussing the endogenous problems may lead to a biased result (Albaladejo et al., 2014). And the spatial correlation of carbon emissions requires a spatial econometric model (Liu and Liu, 2019). Thirdly, little attention is paid on the effect of digitization on the relationship between tourism and carbon emissions.

The aim of this paper is to identify the impact of tourism on carbon emissions with China's provincial panel data over 2001-2015. By constructing a comprehensive indicator of tourism, the impact of tourism on carbon emissions are re-examined through the Generalized Spatial Two-stage Least Square (GS2SLS) model, which is valid in solving the endogenous problems and identifies the spatial spillover effect of carbon emissions. The moderating effect of digitization on the relationship between tourism and carbon emissions is further examined.

2. Methods and Data

2.1. Model Specification

This study introduces tourism to the STIRPAT model proposed by Dietz and Rosa (1994). Considering the EKC hypothesis (Grossman & Krueger, 1995) and the possible non-linear relationship between tourism and carbon emissions, the model is constructed as:

$$\ln C_{it} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln A_{it} + \beta_3 (\ln A_{it})^2 + \beta_4 \ln T_{it} + \beta_5 \ln Tour_{it} + \beta_6 (\ln Tour_{it})^2 + \beta_7 X_{it} + \varepsilon_{it} \quad (1)$$

Where i is the unit of 30 provinces in China (Tibet, Hong Kong, Macao and Taiwan, and South Sea Islands are excluded due to the lack of data), t is the year. C_{it} is the carbon emission

in province i and year t. P_{it} is the population. A_{it} is wealth and T_{it} is technology. $Tour_{it}$ is the tourism, calculated by a sum of variables related to industrial dimension, spatial dimension and integrated dimension of tourism. X_{it} is the vector of control variables, including industrial structure (*SEC*), energy structure (*ES*), openness (*FDI*), environmental regulation (*REG*), β_0-β_6 are the estimated parameters, ε_{it} is the random error.

In addition, digitization and the interaction between digitization and tourism development are included in the model to examine the moderating effect of digitization on the relationship between the tourism industry and carbon emissions.

$$\ln C_{it} = \alpha_0 + \alpha_1 \ln P_{it} + \alpha_2 \ln A_{it} + \alpha_3 (\ln A_{it})^2 + \alpha_4 \ln T_{it} + \alpha_5 \ln Ctour_{it} + \alpha_6 (\ln Ctour_{it})^2 + \alpha_7 \ln Dig + \alpha_8 \ln Ctour_{it} * \ln Dig + \alpha_9 (\ln Ctour_{it})^2 * \ln Dig + \alpha_{10} X_{it} + \varepsilon_{it} \quad (2)$$

2.2. Variables and Data

Carbon emissions are expressed by the carbon dioxide emissions per unit GDP. And the carbon dioxide emissions are calculated based on energy consumption and the emission coefficients derived from the IPCC (2006) (Dhakal, 2009; Liu and Liu, 2019).

Tourism is discussed from industrial dimension, spatial dimension and integrated dimension in this paper, as shown in Table 1. Based on the relevant research of tourism, the evaluation index covers the development efficiency of tourism, the spatial density of tourism infrastructure, the integration of tourism industry and the tertiary sector. The entropy method is used to calculate the weight of the index.

Table 1. Evaluation index system tourism

	Evaluation system	Weight	Evaluation Index	Measuring unit
Tourism	Industrial dimension	0.1962	Proportion of tourism revenue in GDP	%
			Profit margin of tourism enterprises	%
			Total labor productivity of tourism enterprises	1000 yuan/person
	Spatial dimension	0.6998	Railway density	km/km^2
			Highway density	km/km^2
			Number of public transports per 10,000 persons	Unit/10,000 person
			Number of smart tourism city	pes
			Internet penetration	%
	Integrated dimension	0.1040	Proportion of tourism revenue in the tertiary sector	%

Digitization (*Dig*) indicates the internet penetration rate. Population density (*P*) indicates the population density. Wealth (*A*) is the GDP per capita and technical level (*T*) indicates R&D investment per 100 yuan of GDP. Energy structure (*ES*) is characterized by the proportion of coal consumption in energy consumption. Industrial structure (*SEC*) is the ratio of the tertiary sector to secondary industry. Openness (*FDI*) and environmental regulation (*REG*) are measured by the proportion of foreign direct investment in GDP and the ratio of region emission charges to industrial added value, respectively.

This paper uses the panel data of 30 provinces in China to test the effect of tourism on carbon emissions (Tibet, Hong Kong, Macao and Taiwan, and South Sea Islands are excluded due to the lack of data). The main sources of data include The Yearbook of China Tourism, China Statistical Yearbook, China Energy Statistical yearbook and China Information Yearbook.

3. Results and Discussions

The results are shown in Table 2. The Hausman test shows the fixed effect model is used in this section. Moreover, the results of LM test in Table 2 and demonstrates that there is no under-identification for the instrumental variables.

The models of (1)-(2) are the benchmark model, and the results of model (2) show the coefficient of W*ln$C$ is 7.711 and statistically significant at the 10% level. There is a significant spatial spillover effect of carbon emissions. The strategy of co-governance is one of the keys of carbon emissions control (Shi et al., 2021). There is a U-shaped relationship between tourism and carbon emissions for the coefficients of ln*Tour* and (ln*Tour*)^2 are -0.440 and 0.108 respectively. Due to the improvement of industrial efficiency and technological innovation, tourism restrains the improvement of carbon emissions before the knee point. In addition, the environmental regulation of government and the green production of enterprises driven by tourism also have positive effect on the reduction of carbon pollution. However, when tourism reaches the knee point, its further development increases the carbon emissions. The population aggregation caused by tourism poses challenges to the environment carrying capacity and generates negative externality to the environment.

The coefficient of population density is -0.894, indicating that there is a significant negative impact on carbon emissions. The industrialization of China is still in the accelerating stage for the positive impacts of (ln$A$) ^{2} (Gao et al., 2021a; Martinez-Zarzoso and Bengochea-Morancho, 2004). The improvement of technical level increases the carbon emissions in China.

Table 2. The result of GS2SLS model

	Benchmark model		Moderating effect model	
Variable	(1)	(2)	(3)	(4)
W*ln$C$	6.817**	7.711*	2,349***	2,808***
	(3.142)	(3.958)	(425.4)	(540.2)
ln*Tour*	-0.262***	-0.440***	-0.291	-0.635
	(0.049)	(0.120)	(0.284)	(0.389)
$(\ln Tour)^2$		0.108*		0.605**
		(0.063)		(0.259)
ln*Tour**ln*Dig*			-0.0147	-0.0500
			(0.0691)	(0.124)
$(\ln Tour)^2$*ln*Dig*				-0.116**
				(0.0585)
ln*Dig*			0.0216	0.150
			(0.0762)	(0.107)
ln$P$	-0.673***	-0.894***	-0.185	0.00782
	(0.172)	(0.250)	(0.177)	(0.202)
ln$A$	-0.137***	0.004	-1.345**	-2.342***
	(0.042)	(0.097)	(0.606)	(0.786)
$(\ln A)^2$	0.052***	0.043**	0.0551**	0.103***
	(0.015)	(0.020)	(0.0271)	(0.0367)
ln$T$	0.130***	0.133**	0.0461*	0.0503
	(0.043)	(0.054)	(0.0261)	(0.0311)
ln*SEC*	0.011	0.015	0.000779	0.0404
	(0.049)	(0.062)	(0.0501)	(0.0519)
ln*ES*	0.247***	0.237**	0.208***	0.168***
	(0.080)	(0.100)	(0.0325)	(0.0362)
ln*FDI*	0.031**	0.041**	0.0356***	0.0224
	(0.016)	(0.020)	(0.0132)	(0.0144)
ln*REG*	0.180**	0.156	0.127***	0.108***
	(0.081)	(0.102)	(0.0228)	(0.0251)
Constant	5.632***	6.625***	10.81***	14.51***
	(0.997)	(1.372)	(3.024)	(3.739)
R^2	0.0167	0.4648	0.7421	0.6491
Wald test	5712.123	3665.623	5736.625	5909.883
(p)	(0.000)	(0.000)	(0.000)	(0.000)
LM test	129.693	141.648	264.7728	312.4131
(p)	(0.000)	(0.000)	(0.000)	(0.000)

Note: t-values are placed in parentheses under the coefficient values; *means significant at confidence level 10%, **means significant at confidence level 5%, ***means significant at confidence level 1%.

The models of (3)-(4) are the moderating effect model, the results of model (4) show the coefficient of $(\ln Tour)^2$*ln*Dig* is -0.116 and is significant at the 5% level, indicating that digitization can significantly weaken the positive effect of tourism on carbon emissions. It is conducive to the low-carbon development of tourism. Therefore, more attention should be paid to the digital transformation of tourism.

4. Conclusion and Policy Implications

By subdividing the development of tourism into industrial dimension, spatial dimension and integrated dimension, this study proffers a new insight on the role of tourism towards China's emissions peak with the STIRPAT model and GS2SLS model over the periods from 2001 to 2015. The moderating effect of digitization on the relationship between tourism and carbon emissions is further examined.

Empirical results provide enough significant evidence of spatial spillover effect of the carbon emissions. Carbon reduction should follow the principle of joint defense for the spatial spillover effect of the carbon emissions. The empirical also show that there is a U-shaped relationship between tourism and carbon emissions in national level. Considering the carbon pollution of tourism in the long-term, more attentions are needed on the low-carbon development of tourism. Digitization inhibits the positive effect of tourism on carbon emissions. More attention should be paid to the digital transformation of tourism in the process of low-carbon

development.

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