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The Impact of the Digital Economy on the Carbon Emission Intensity of Tourism

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ABSTRACT
This paper presents an empirical analysis of the impact of digital economy development on the carbon emission intensity of tourism in China. The analysis is based on panel data from 31 provincial administrative units across China from 2011 to 2020. The spatial Durbin model is used to investigate the relationship between digital economy development and carbon emission intensity in the tourism sector. The findings indicate that: The expansion of the digital economy exerts a negative spatial spillover effect on the carbon emission intensity of the tourism industry. Furthermore, the development of the digital economy has a more pronounced impact on the neighbouring region's carbon emission reduction than on the local area.

KEYWORDS
digital economy; carbon emission intensity tourism; spatial spillover effect

1 Introduction

In recent years, China's economy has been actively responding to global climate change, addressing the dual challenges of increasing resource scarcity and environmental degradation. In this context, a detailed plan has been formulated with the objective of achieving carbon peaking by 2030 and carbon neutrality by 2060. In this context, the pursuit of green development is not merely an inevitable choice for the protection of the environment and the realisation of sustainable development, but also an urgent task for the purpose of coping with the current economic situation.

Concurrently, the digital economy is experiencing a period of rapid growth on a global scale, emerging as a new and significant economic force. Empirical evidence suggests that this new economic form not only stimulates economic growth and enhances industrial efficiency, but also reduces reliance on traditional energy sources to a certain extent, thereby reducing carbon dioxide emissions[1].

Tourism constitutes an essential component of the national economy, facilitating regional economic growth. However, it is not a "green industry" in the conventional sense[2].

The tourism industry is currently undergoing a shift from an object-based approach to a people-based one. This shift has highlighted the urgent need to resolve the question of how to achieve a harmonious coexistence between tourism development and carbon emission reduction goals. In light of this, this paper presents a spatial Durbin model, with the objective of investigating the impact of the development level of the digital economy on the carbon emissions of the tourism industry. The findings will inform the formulation of more accurate emission reduction strategies.

2 Theoretical analysis and research hypothesis

2.1 Impact of the digital economy on the carbon emission intensity of the tourism industry

The digital economy exerts an influence on the carbon emission intensity of the tourism industry, promoting the intelligent and low-carbon transformation of the tourism industry.

Primarily, the digital economy facilitates the intelligent development of the tourism industry, influencing the carbon emission intensity through intelligent energy management, intelligent traffic management, intelligent material supply chain management, and intelligent energy-saving facility application. Secondly, the digital economy plays an instrumental role in the decarbonisation of the tourism industry, exerting a profound impact on the carbon emission intensity of the tourism industry in numerous ways and facilitating the transition of the tourism industry towards a low-carbon trajectory. Concurrently, the digital economy has facilitated the proliferation of environmentally conscious transportation and travel options.

The advent of novel transportation modalities, including shared bicycles, electric vehicles, and intelligent public transport systems, has prompted tourists to gravitate towards environmentally conscious modes of travel, effectively curbing the carbon emission intensity of conventional transportation methods. Conversely, the digital economy has facilitated the growth of virtual tourism and telecommuting. Through the use of virtual reality and augmented reality technologies, tourists are able to experience scenic locations without the need for physical travel, thereby reducing the demand for transport and energy associated with traditional tourism. Furthermore, the digital economy has promoted the development of digital marketing and online booking systems within the tourism industry. The implementation of digital technologies facilitates more convenient planning of travel routes and the booking of services, thereby enhancing operational efficiency within the tourism industry.

This, in turn, results in a reduction in the use of paper documents and manpower costs, which subsequently leads to a decrease in the intensity of carbon emissions. In conclusion, the following hypotheses are proposed in this paper:

H1: It is hypothesised that the digital economy has the potential to reduce the carbon emission intensity of the tourism industry.

2.2 The spatial spillover effect of the digital economy on the carbon emission intensity of the tourism industry

The digital economy has a pronounced spatial spillover effect, which disrupts the conventional mode of information transmission. It serves as a conduit for the dissemination of information, knowledge, experience, technology, and more, fostering communication and learning between regions, expanding the scope of propagation, and accelerating the rate and frequency of its diffusion. It is proposed that the digital economy in the region can assist the tourism industry in reducing carbon emissions, thereby achieving the objective of a "green, low carbon and high quality" industry.The "demonstration effect" of the digital economy in the low-carbon, high-quality development of the tourism industry can provide neighbouring regions with practical experience, and promote the spillover of green technology, knowledge and experience from neighbouring regions, thus reducing the carbon intensity of the tourism industry in the region. Therefore, this paper proposes the following hypothesis:

H2: The digital economy has a negative spatial spillover effect on the carbon emission intensity of tourism.

3 Research Design

3.1 Model Construction

This section explores the impact of the digital economy on the carbon emissions of the tourism industry through the use of benchmark regression analysis. The benchmark model is set up as follows:

$$TCI_{it}=\alpha_0+\alpha_1 DEI_{it}+\gamma X_{it}+\varepsilon_{it} \quad (1)$$

Secondly, the traditional linear regression model is constrained by its inability to account for spatial correlation. However, the spatial Durbin model incorporates lagged terms between explanatory and explained variables, thereby circumventing the potential bias introduced by the exclusion of variables. Accordingly, this paper proposes the utilisation of the spatial Durbin model (SDM) to investigate the influence of the digital economy on the carbon emission intensity of the tourism industry. The SDM exhibits greater applicability than the spatial error model and the spatial lag model, as evidenced by the following expression:

$$TCI_{it}=\alpha_0+\rho WTCI_{it}+\alpha_1 DEI_{it}+\beta_1 WDEI_{it}+\gamma X_{it}+\mu_i+v_t+\varepsilon_{it} \quad (2)$$

3.2 Variable Construction

The dependent variable is the tourism carbon emission intensity (TCI). The term "carbon emission intensity of tourism" is defined as the quantity of carbon emissions produced by tourism activities, expressed as a ratio relative to revenue. This paper employs the research methodology of Wang Kai[3] et al. The carbon dioxide emissions of the tourism sector are classified into three categories: transport, accommodation and leisure. The carbon dioxide emissions produced by each sector are calculated and aggregated. In this study, the proportion of carbon emissions from the regional tourism sector in the total revenue of the tourism industry is selected as the primary indicator for measurement.

The core explanatory variable is the level of development of the digital economy (DEI). In light of the research conducted by Chen Bowen[4], this paper considers the representativeness and availability of data in the context of China's national conditions. It integrates multi-level and multi-dimensional indicators into a comprehensive index and establishes an index system for the digital economy at three levels: digital platform, digital industry, and digital innovation. In consideration of the availability of data, this paper selects the statistics from 2011 to 2020 and employs the entropy value method to assess the digital economy development status of the 31 provincial administrative units in China.

The following variables are employed as control variables: In accordance with the research of Cha Jianping[5] and others, the following control variables have been selected: industrial structure, scientific and technological innovation level, economic development level and foreign direct investment.

4 Analysis of empirical results

4.1 Spatial autocorrelation test

It is self-evident that model testing is a prerequisite for space-based statistical analysis. In the case of the LM test, the results of the SEM and SAR models failed to meet the 1% level of significance, which rendered the traditional OLS model invalid. However, the R-LM-Lag model did not pass the Robust-LMr test, indicating The Dubin model is required for this purpose. To corroborate this hypothesis, we will employ the SDM and Wald tests to substantiate the hypothesis

of SDM degeneration. The LR, Wald, and other tests all passed the 1% significance level, rejecting the original assumption and indicating that the SDM cannot undergo degeneration. Consequently, we have selected the Dubin model as the analytical tool for this study in spatial econometric analysis.

The overall Moran index demonstrates an initial increase, followed by a subsequent decline, exhibiting a fluctuating upward trend from 2011 to 2016. The Moran index rises from 0.0779 in 2011 to 0.0896 in 2017, indicating that the spatial agglomeration characteristics of carbon emissions in China are markedly strengthened during this period. From 2017 onwards, the Moran index declined from 0.0896 to 0.0483, indicating that the spatial agglomeration of China's carbon emissions was gradually weakening during that period.

Table 1 Global Moran's index of carbon emission intensity of tourism in China's provinces

Year	Moran's I value	Z value	P value
2011	0.0779	3.0220	0.0025
2012	0.0624	2.5844	0.0098
2013	0.0600	2.5125	0.0120
2014	0.0277	1.6591	0.0971
2015	0.0538	2.4163	0.0157
2016	0.0683	2.7666	0.0057
2017	0.0896	3.2672	0.0011
2018	-0.0327	0.0174	0.9861
2019	0.0176	1.3555	0.1753
2020	0.0483	2.6623	0.0078

4.2 Decomposition of the spatial spillover effect

This paper aims to examine the impact of digital economy development on carbon emission reduction in local and neighbouring areas by decomposing the spatial effect on the carbon emission intensity of tourism. The results demonstrate that in the direct effect, the regression coefficient for the level of digital economy development is 0.098. However, in the indirect effect, the regression coefficients of the digital economy reach -2.084 and -1.986, respectively. This indicates that an increase of 1% in the digital economy development index will result in a significant reduction of 2.084% in the carbon emission intensity of neighbouring areas through the indirect effect. From the standpoint of the overall impact, the local carbon emission intensity will be reduced by 1.986 per cent. This finding corroborates the hypothesis that the rapid development of the digital economy will have a significant effect on the carbon emission level of neighbouring regions, exhibiting substantial negative spatial spillovers.

Table 2 Decomposition of the spatial spillover effect

variable names	total effect	direct effect	indirect effect
DEI	-1.986**	0.098	-2.084**
	(-2.14)	(1.63)	(-2.30)
INS	0.510***	0.038**	0.472***
	(2.79)	(2.51)	(2.65)
TDL	0.138**	0.019***	0.119***
	(2.55)	(3.97)	(2.31)
EDL	2.479***	0.024	2.455***
	(2.91)	(0.39)	(2.94)
FDI	-0.601***	-0.106***	-0.495***
	(-3.16)	(-7.90)	(-2.72)
N	310	310	310

***, **, * indicate significant at the 1 per cent, 5 per cent and 10 per cent levels, respectively.

5 Recommendations

It is recommended that the integration of digital technologies with the tourism industry be strengthened in order to facilitate the development of digital tourism. It is recommended that the tourism industry assume the initiative in integrating digital technologies, expanding the application of digital technologies in the tourism sector, promoting the digital transformation of tourism venues such as scenic spots and hotels, and establishing a tourism digital information platform to enhance connectivity between the supply and demand sides of the tourism market.

Secondly, It is imperative that the government fully recognises the positive role of the digital economy in reducing emissions in the tourism industry, and seizes this opportunity to promote the digital transformation of the tourism industry. It is therefore incumbent upon the government to provide the requisite support and guarantees, rationalise the allocation of special digital funds and prioritise support for the construction of key infrastructures, including cloud computing, big data and the Internet of Things (IoT).

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