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The coordination pattern of tourism efficiency and development level in Guangdong Province under high-quality development

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Tourism efficiency is an important basis for measuring the quality of regional tourism economic operations. Promoting the high-quality and sustainable development of tourism is of great theoretical significance and practical value. Here, we measured the tourism development level of 21 cities in Guangdong Province from 2000 to 2020, introduced the DEA-MI model to measure and dissect tourism efficiency, and analyzed spatiotemporal data to explore the dynamic characteristics of regional tourism differences and spatial structures. Additionally, we constructed a coupled coordination degree model of tourism efficiency and development level and analyzed the coupling excellence and synergistic consistency of the two models. The results showed (1) evident spatial differences in the comprehensive tourism efficiency of 21 cities in Guangdong Province. (2) The local spatial structure of the tourism efficiency and development level fluctuates less and is more stable depending on the direction. (3) The local spatial structure of the tourism development level is more stable because the relative positions of municipal units are not readily changed. (4) The overall coupling degree of tourism efficiency, scale, and coupling coordination degree gradually improve with similar spatial and temporal divergence characteristics; the local evolution shows spatial heterogeneity and volatility.

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Introduction

China's economy has shifted from a high-speed growth stage to a high-quality development stage. The promotion of industrial transformation and upgrading, along with the improvement of quality and efficiency, are necessary conditions for achieving high-quality economic development. Tourism transformation and high-quality development are realistic requirements and important focal points of China's economic and social development in the new stage. High-quality tourism development requires the continuous optimization of industrial structure, industrial efficiency, and the ecological environment. This improves the quality and efficiency of the tourism industry, promotes its transformation and upgrading, and realizes the unity of its economic, social, and ecological benefits. Tourism serves as an important strategic pillar of the national economy, fostering employment, benefiting the livelihood of people, and promoting economic transformation and upgrading. Since the reform and opening up, the cultural and tourism industries in Guangdong Province have developed rapidly, with continuous growth in scale and significantly enhanced comprehensive strength. The province's cultural industry-added value, total tourism revenue, and foreign exchange revenue from tourism have consistently ranked first in the country. According to the approval of the statistical department, the added value of cultural and related industries in Guangdong Province increased from 364.8 billion yuan in 2015 to 622.7 billion yuan in 2019, accounting for about 1/7 of the national total and ranking first in the country for 18 consecutive years; The proportion of GDP in the province increased from 5.01% in 2015 to 5.77% in 2019. The total tourism revenue of the province increased from 908.1 billion yuan in 2015 to 1515.8 billion yuan in 2019; The number of overnight tourists received increased from 362 million in 2015 to 531 million in 2019. Since 2020, due to the impact of the pandemic, the tourism industry has been severely affected, and the number of tourists has significantly decreased. In 2020, the number of tourists in Guangdong Province decreased to 231 million, and there was a slight recovery in 2021, with the number of tourists increasing by 11.46% to 257 million. And there is a significant gap in tourism efficiency and development level among cities in Guangdong Province. Therefore, this study takes Guangdong Province as a typical representative to promote coordinated development of the tourism industry and enhance regional tourism competitiveness (Zhang et al., 2023).

Tourism efficiency is a comprehensive indicator that reflects the utilization level of tourism development resources and the sustainable development ability of tourism. Improving tourism efficiency plays an important role in promoting the transformation of the tourism economy and the sustainable development of the tourism industry (Qiao et al., 2023). Tourism efficiency refers to obtaining the maximum output of tourism-related resources with minimal input within a certain time frame to meet the needs of stakeholders and maximize the total surplus. This reflects the rationality of tourism growth (Li et al., 2014). The study of tourism efficiency is of great significance for its high-quality development. The rapid growth of the tourism economy has attracted the attention of the academic community, which aims to coordinate the development of the tourism economy. Regional tourism differences and spatial structures have become a research hotspot, including in-depth research on topics such as tourism, regional tourism development, and ecotourism that have achieved important results (Fang and Huang, 2020; Han, 2018). At present, scholars' research trends on tourism efficiency are mainly reflected in the following aspects: (1) the research content has shifted from single tourism efficiency evaluations, such as management efficiency (Bacos and Gabor, 2021), operational efficiency (Tang, 2021), and tourism transportation efficiency (Wang et al., 2021), to comprehensive efficiency

evaluations such as tourism ecological efficiency (Li et al., 2020), tourism poverty alleviation efficiency (Wang and Guo, 2018), and regional tourism efficiency (Sun, 2019). (2) The research methods have gradually shifted from qualitative evaluation of tourism efficiency to comprehensive quantitative analysis using multiple models such as data envelopment analysis (Wang et al., 2020), the SBM Malmquist model (Liu et al., 2021), and the DEA-SNA model (Wang et al., 2020). (3) The research areas have transformed from large-scale regions such as national level (He and Wang, 2020), provincial level (Xu et al., 2018), and Yangtze River Delta (Wang et al., 2016) to medium-sized regions such as national-level scenic spots (Cao et al., 2014) and A-level tourist attractions (Zhou et al., 2021). (4) The depth of research has shifted from exploring the spatiotemporal variation characteristics of tourism efficiency (Ma and Bao, 2009) to exploring the driving mechanisms (Pan et al., 2021) of its spatiotemporal differentiation with factors such as the natural environment (Massidda and Etzo, 2012; Seetaram, 2012), economic development level (Dritsakis, 2012; Pablo et al., 2015), tourism resource endowment (Liao et al., 2022; Ramona et al., 2017), transportation conditions (Nina, 2020; Purnomo et al., 2020), and human institutional supply (Munro et al., 2019).

Studies related to regional tourism differences and tourism spatial structure are generally more comprehensive, but some limitations remain. Efficiency and development levels have been given equal importance in the era of high-quality tourism growth; however, comprehensive measures of tourism quality according to tourism efficiency and development level are limited. Classic statistics and exploratory spatial data analyses primarily measure cross-sectional characteristics of spatial association and interaction mechanisms (Ye and Carroll, 2011). Overall, studies that ignore the spatial dimension and static studies that ignore the temporal dimension have revealed only limited regional differences. A tourism region is a composite geographic system that gathers multiple functions that are constantly adjusting. To more comprehensively reveal the dynamic divergence law of regional tourism development, temporal and spatial attributes must be combined when exploring regional differences and spatial structures.

This study builds upon previous research results (Fang and Huang, 2020) and aims to (1) measure the tourism development level of 21 cities in Guangdong Province from 2000 to 2020, (2) determine and dissect tourism efficiency using the data envelopment analysis (DEA-BCC) model and Malmquist productivity index, and (3) explore the dynamic evolution of the local tourism spatial structure using the local indicators of spatial association (LISA) time path and spatiotemporal leap based on the exploratory spatiotemporal data analysis framework proposed by Rey and Janikas (2006). Moreover, the coupling and coordination model of tourism efficiency and development level is constructed, and their relationship is examined. This study offers a novel research perspective on the deep coupling of regional tourism space-time evolution and provides a scientific basis for improving the quality, efficiency, and coordinated and sustainable development of regional tourism.

Research methods and data sources

Research methods

Exploratory spatiotemporal data analysis. Exploratory spatiotemporal data analysis is used to describe the structural characteristics of urban unit tourism efficiency and development level. It systematically analyzes the spatial distribution of time-based behavior and the temporal evolution of spatial patterns, thereby compensating for the shortcomings of exploratory spatial data analysis in the time dimension (Bi et al., 2018).

(1) *LISA spatiotemporal path*: The LISA space–time path is used to measure the stability of the LISA coordinates, which consist of attribute variables and spatial lags in the Moran scatter plot. They explain the spatiotemporal cooperative changes and dynamic characteristics of regional tourism efficiency and development level. Geometric features include path length, curvature, and jump direction. The LISA spatiotemporal path length can effectively reflect the dynamic characteristics of the local spatial structure of the region, which is calculated as follows (Rey and Janikas, 2006):

$$d = \frac{N \sum_{t=1}^{T-1} d(L_{i,t}, L_{i,t+1})}{\sum_{i=1}^N \sum_{t=1}^{T-1} d(L_{i,t}, L_{i,t+1})}, \tag{1}$$

where N is the number of geographic units; T is the annual interval; $L_{i,t}$ is the LISA coordinate of unit i in year t ; $d(L_{i,t}, L_{i,t+1})$ is the distance that geographic unit i moves from year t to year $t + 1$.

The curvature of the LISA time path can effectively reflect the fluctuation characteristics of the local spatial structure in the region, which is calculated as follows (Nina, 2020):

$$f = \frac{\sum_{t=1}^{T-1} d(L_{i,t}, L_{i,t+1})}{d(L_{i,1}, L_{i,T})}, \tag{2}$$

where $d(L_{i,1}, L_{i,T})$ is the distance traveled by geographical unit i from year one to year one. When the f value is increased, the LISA time path and local spatial structure fluctuation become more curved.

(2) *LISA spatiotemporal leap*: Rey et al. (Rey and Janikas, 2006) embedded the time path attribute of LISA into the traditional Markov chain, proposing a transition probability matrix and a spatiotemporal transition theory. The time-space transformation method is used to assess the transformation state of local spatial correlation patterns between tourism efficiency and development level in each city. Spatiotemporal transformation can be divided into four distinct categories based on the migration state: type I (self-leap and neighborhood stable), type II (self-stable and neighborhood leap), type III (both self and neighborhood leap), and type IV (both self and neighborhood stable) (Table 1). The HH and LL types exhibit a strong positive spatial correlation, indicating regional clustering and similarity. The HL and LH types exhibit a negative spatial correlation, indicating regional dispersion and heterogeneity.

Coupling coordination degree model. The coupling degree quantitatively measures the degree of interaction between two or more systems. Referring to related research results and combining the research reality, the coupling degree model of tourism efficiency and development level was constructed as follows

(Zhang et al., 2013):

$$C = \{f(x)g(y)/[(f(x) + g(y))/2]^2\}^k, \tag{3}$$

where C is the coupling degree of tourism efficiency and development level, $0 < C < 1$ (the larger the value of C , the better the coupling); $f(x)$ and $g(x)$ are the tourism efficiency and development level indices, respectively; k is the adjustment coefficient, generally $2 \leq k \leq 5$ (the coupling degree model in this study consists of two subsystems, such that the value of k was set as 2).

The model was used to further assess the coupling coordination between tourism efficiency and development level, as well as the consistency characteristics of the synergistic effect and overall efficacy of both, and was calculated as follows (Wang and Tang, 2018):

$$D = \sqrt{C \times T}, T = \alpha f(x) + \beta g(y), \tag{4}$$

where D is the coupling coordination degree of the tourism efficiency and development level; T is the comprehensive coordination index of both; α and β are coefficients to be determined. The two subsystems of tourism efficiency and development level were considered equally important, i.e., $\alpha = \beta = 0.5$.

Indicator selection and data sources. The measurement results for tourism efficiency mainly depend on input and output indicators. For input indicators, the most basic factors of production in classic economics include land, labor, and capital (Wang et al., 2017). Tourism activities are less constrained by the land factor. Obtaining data on municipal tourism land is difficult; therefore, most studies do not include it in the input variable indicators (Zhang et al., 2005). Tourism employees are the most direct providers of tourism services and their number is the most useful measure of the labor factor. However, most cities do not record statistics on this indicator; therefore, the number of employees in the tertiary industry was selected instead. This indicator amplifies the input scale of the labor factor but partially considers the comprehensive nature of the tourism industry. Capital provides important support for tourism activities, but official statistics on fixed investment in tourism are unavailable in most cities. Therefore, a 3 A (or three-star) or higher grade can reflect the high status of tourism resources and services. The number of 3A (or 3-star) and above tourist attractions, star-rated hotels, and travel agencies was used as an alternative input indicator for the capital factor. For the output indicators, the most direct output of tourism activities, namely the total number of tourist arrivals and total tourism revenue, were selected as the main indicators. To maintain data consistency and comparability of results, the tourism development level measurement also used two indicators, namely total tourism headcount and revenue, to construct the tourism development level measurement model:

$$SP_n = \sum_{i=1}^n P_i S_i, \tag{5}$$

where P_i is the weight, calculated by applying the entropy value method, and S_i is the dimensionless value of indicator i . Meanwhile, the total tourism revenue was deflated using the consumer price index of each year, with the base period in 2000, to eliminate the influence of price fluctuations.

This study focused on Guangdong Province (see Fig. 1), encompassing a total of 21 cities divided into four regions: Pearl River Delta, East Guangdong, West Guangdong, and North Guangdong. Pearl River Delta: Guangzhou, Shenzhen, Foshan, Dongguan, Zhongshan, Zhuhai, Jiangmen, Zhaoqing, Huizhou; East Guangdong: Shantou, Chaozhou, Jieyang, Shanwei; West Guangdong: Zhanjiang, Maoming, Yangjiang; North Guangdong:

Table 1 Type of space-time transition.

Type	Time leap form	Symbolic expressions
Type I	Self-jumping-neighborhood stabilization	HH _t → LH _{t+1} , LH _t → HH _{t+1} , HL _t → LL _{t+1} , LL _t → HL _{t+1}
Type II	Self-stabilization-neighborhood leap	HH _t → HH _{t+1} , LH _t → LH _{t+1} , HL _t → HL _{t+1} , LL _t → LL _{t+1}
Type III	Self-jumping-neighborhood jumping	HH _t → LH _{t+1} , LH _t → HH _{t+1} , LL _t → HL _{t+1} , HL _t → LL _{t+1}
Type IV	Self-stabilization-neighborhood stabilization	HH _t → HH _{t+1} , HH _t → HH _{t+1} , LL _t → LL _{t+1} , LL _t → LL _{t+1}

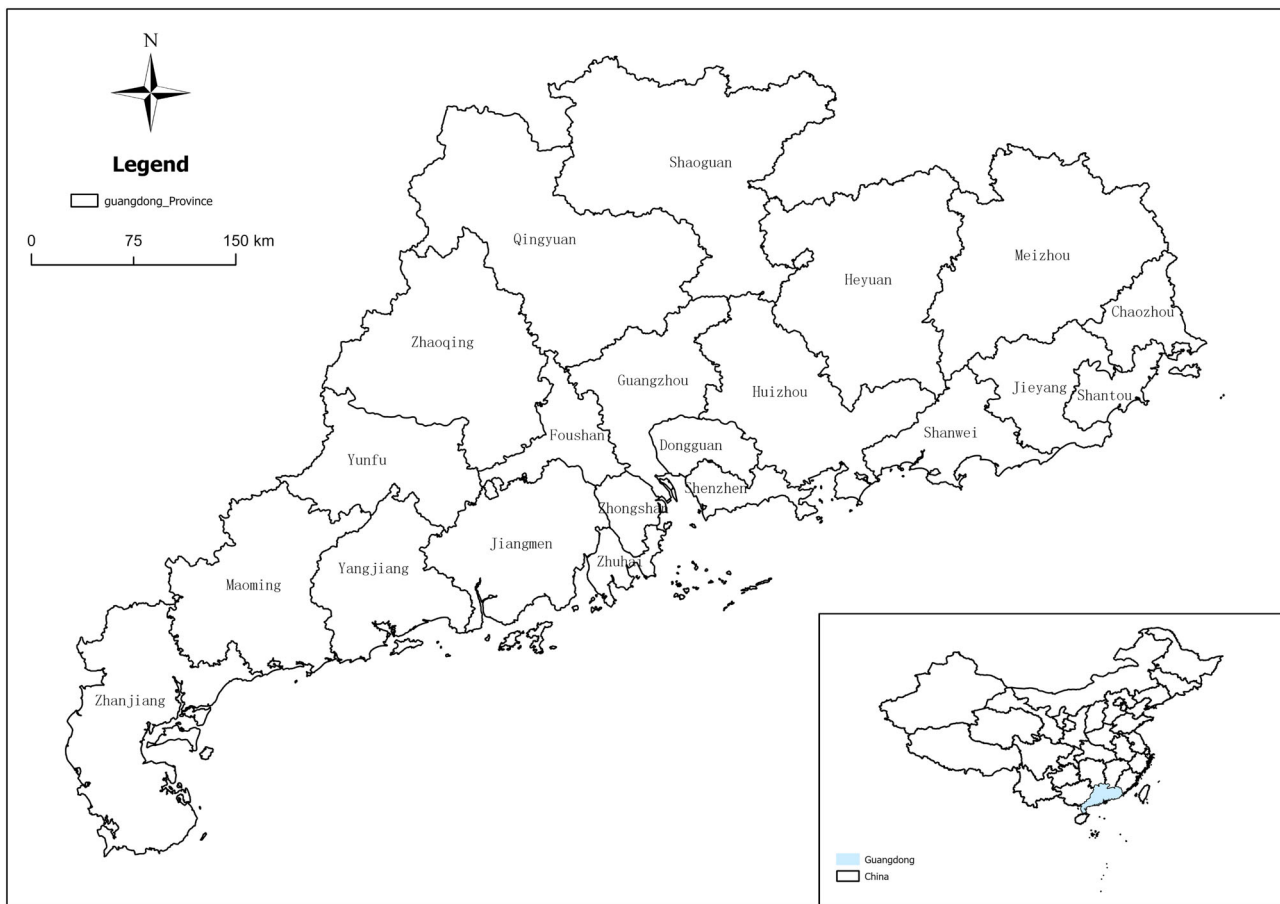


Fig. 1 Study area. This study focuses on Guangdong Province, which comprises 21 cities segregated into four regions: Pearl River Delta (Southern Guangdong), Eastern Guangdong, Western Guangdong, and Northern Guangdong.

Shaoguan, Qingyuan, Yunfu, Meizhou, Heyuan. As a major economic and tourism province in China, Guangdong has cultivated and created a large number of high-quality tourism enterprises and projects, gradually building a relatively complete tourism public service system and forming a relatively mature market investment environment. In 2021, Guangdong Province received 201 million overnight tourists, an increase of 7.97% compared to the previous year, and achieved a total tourism revenue of 543.373 billion yuan, an increase of 15.84%. Vector data of administrative divisions of 21 cities in Guangdong Province were extracted from 17,000 administrative division maps of China obtained from the National Bureau of Surveying and Mapping Geographic Information. The data mainly originate from the “Guangdong Provincial Statistical Yearbook,” “Tourism Yearbook,” and “Statistical Bulletin of National Economic and Social Development from 2000 to 2002”. We calculated and supplemented the missing indicator data using the indicator smoothing method.

General characteristics of tourism efficiency and development level in Guangdong Province

Static characteristics of tourism efficiency and development level in Guangdong Province. The DEA-BCC model was used to measure the tourism efficiency of 21 cities in Guangdong Province from 2000 to 2020. The average values of tourism efficiency, pure technical efficiency, and scale efficiency of each city unit were calculated. The measurement results were divided into five grades: low efficiency, medium efficiency, medium efficiency, medium efficiency, and high efficiency (see Fig. 2).

The tourism development level index varied significantly; therefore, its value was normalized to more clearly reflect the overall dynamics of the average tourism development level situation. The logarithmic mean value of the tourism development level in Guangdong Province increased from 0.012 in 2000 to 0.067 in 2020, showing an annually increasing trend. Using the natural breakpoint method, the measured results of the logarithmic mean of tourism development levels were divided into five scales: small scale, small-medium scale, medium scale, medium-large scale, and large scale; the critical values of each scale were 0.0175, 0.03, 0.0425, and 0.0622, respectively, and the overall mean value was 0.047, which was at the medium scale. Six, seven, three, three, and two cities were at each scale, respectively. The number of small, small-medium, and medium-scale cities accounted for 90.47% of the total, showing that the tourism development level of the majority of cities in Guangdong Province has room for growth. Furthermore, the high-value areas of scale were concentrated in cities such as Zhanjiang and Foshan, which have high tourism investment and strong tourism demand.

Dynamic characteristics of tourism efficiency. The Malmquist index model was used to analyze the specific impact of technical efficiency and technological progress on total factor productivity and further analyze the dynamic change process of tourism efficiency in Guangdong Province (Table 2). The average value for the total factor productivity of tourism development in Guangdong municipalities from 2000 to 2020 was 1.200, with annually increasing tourism intensification. In 2004, 2006–2008, and

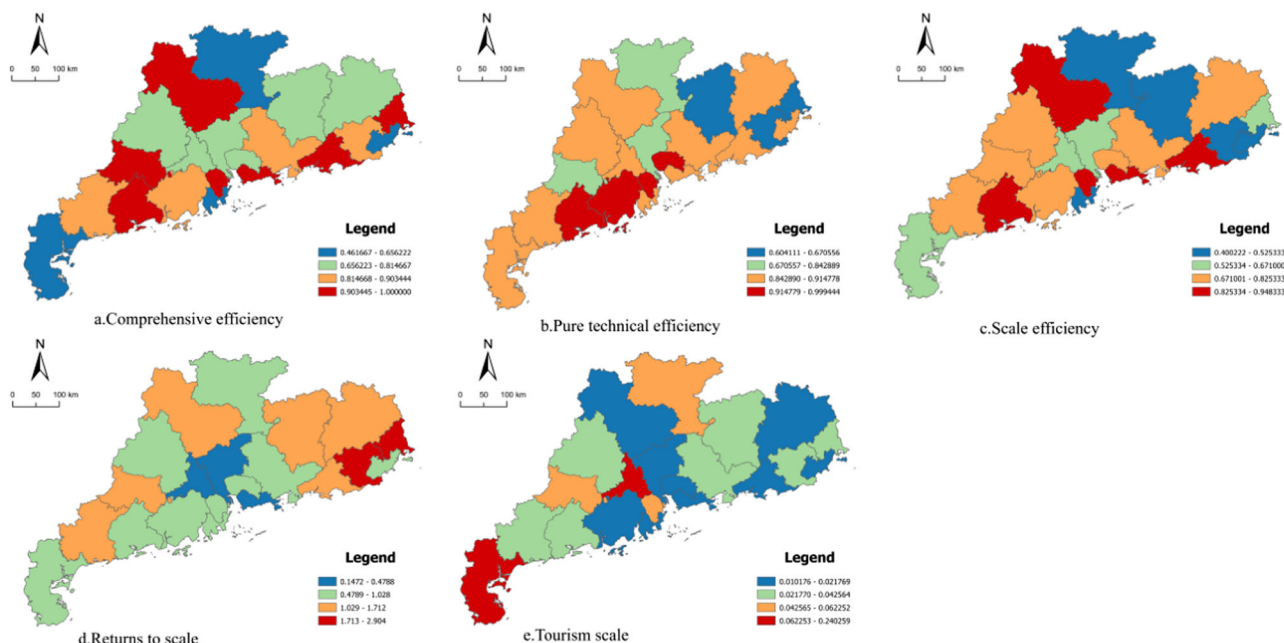


Fig. 2 Average performance of the tourism static efficiency and tourism development level in Guangdong Province from 2000 to 2020. The overall average values of the overall tourism efficiency, pure technical efficiency, and scale efficiency were calculated for each municipal unit. The measurement results were classified into five levels: low efficiency, medium-low efficiency, medium efficiency, medium-high efficiency, and high efficiency.

Table 2 Malmquist production index and its decomposition of tourism efficiency in Guangdong Province from 2000 to 2020.

Period	EFFCH	TECHCH	PECH	SECH	TFPCH
2000-2001	1.0170	0.2636	1.0087	1	0.2658
2001-2002	1.0393	0.7814	1.0356	1	0.8457
2002-2003	1.0004	0	0.9977	1	0
2003-2004	0.9004	0	0.8871	1	0
2004-2005	1.1818	0.5085	1.1644	1	0.6384
2005-2006	0.9993	1.1543	0.9974	1	1.1540
2006-2007	0.8743	2.1181	0.8578	1	1.8428
2007-2008	0.8815	1.0473	0.8693	1	0.9122
2008-2009	1.0872	0.9853	1.0619	1	1.0241
2009-2010	1.1105	0.9289	1.0640	1	1.0248
2010-2011	1.0647	0.6715	1.0369	1	0.6982
2011-2012	1.0156	2.3851	1.0114	1	2.4472
2012-2013	1.1178	0.5366	1.0930	1	0.6043
2013-2014	0.8720	0.2713	0.8263	1	0.2761
2014-2015	1.0269	7.0744	1.0193	1	7.0744
2015-2016	1.1768	1.5189	1.1543	1	1.7736
2016-2017	0.8688	0.3889	0.8520	1	0.3180
2017-2018	1.2436	1.2466	1.2154	1	1.6248
2018-2019	0.9490	0.9524	0.9391	1	0.9206
2019-2020	1.0784	0.5318	1.0739	1	0.5610
Average value	1.0253	1.1682	1.0026	1	1.2003

EFFCH, TECHCH, PECH, SECH, and TFPCH denote the changes in integrated efficiency, technological progress, pure technical efficiency, scale efficiency, and total factor productivity, respectively.

2011-2014, total factor productivity declined to three different degrees. The large-scale severe acute respiratory syndrome (SARS) pandemic, financial crisis, and sudden haze events weakened the positive impact of factors such as technological progress on tourism. They also indirectly indicate that tourism development in Guangdong Province has not yet eliminated its rough characteristics.

The mean value of the comprehensive efficiency change was 1.025, indicating that the overall quality is improving. The effect of the Guangdong Province’s attention to tourism and in-depth promotion, which acts on development efficiency, is gradually emerging. Total factor productivity was higher than the comprehensive efficiency change, indicating that the improvement in comprehensive efficiency was not the cause of the total factor productivity. In contrast, the significant improvement in technological progress was the main factor in maintaining the province’s growth. The index of technological progress change showed fluctuations, with a mean value of 1.168, indicating that the technological level changed significantly and the efficiency of each factor fluctuated. The mean value of pure technical efficiency was 0.816, while the pure technical efficiency change index was <1 for 7 years and >1 for 13 years, with a mean value of 1.025. Pure technical efficiency generally showed a fluctuating trend and did not fully exert its technical and resource potential. The changes in pure technical and development level efficiency in the same period increased most of the time. The pure technical efficiency amplitude range was larger, which indicates that its change was more notable than that of the scale efficiency change, thus changing the comprehensive efficiency. The mean value of the scale efficiency was 0.856, while that of the scale efficiency change was 1, indicating that the scale efficiency was lower and remained unchanged. In the case of the basic unchanged scale efficiency and technological progress, the comprehensive efficiency showed an overall fluctuating downward trend, indicating that the tourism factor configuration is unreasonable and resources are used inefficiently. This is the main reason for the low quality of tourism development. Tourism development is in an urgent period of transformation and requires upgrades; therefore, we should focus on maintaining the scale of tourism or simultaneously reasonably expand the scale efficiency of tourism, explore the potential of tourism resources, increase science and technology, invest in talent, improve the effectiveness of regional collaboration, promote the comprehensive efficiency of tourism, and accelerate high-quality tourism development.

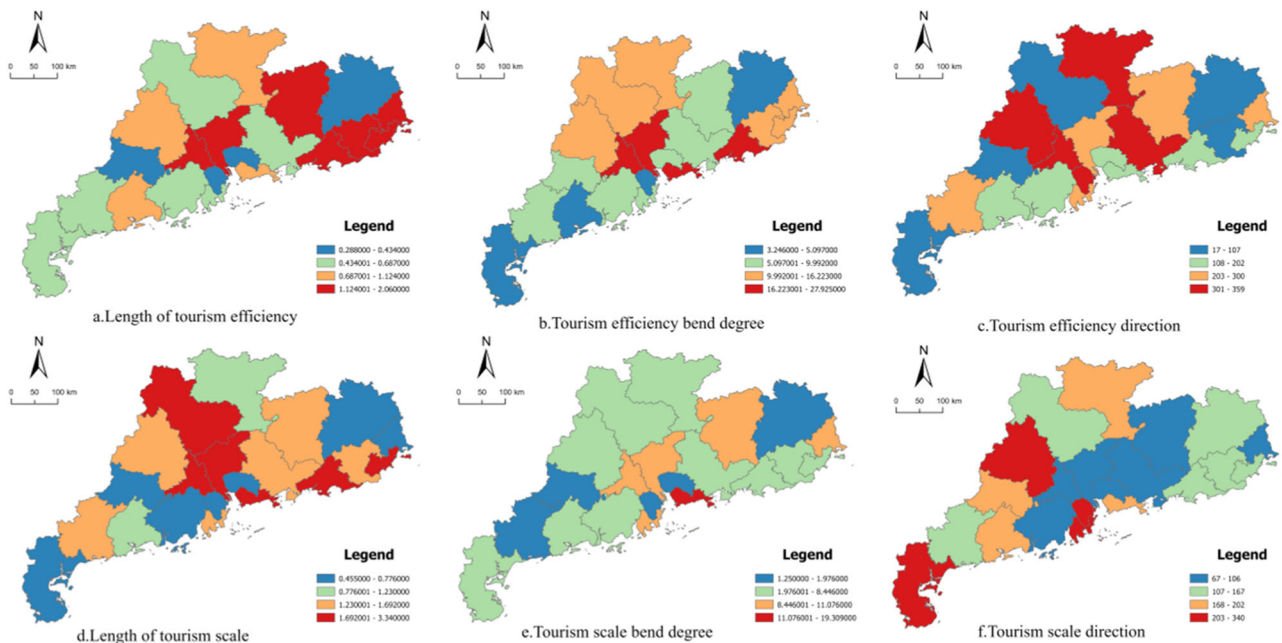


Fig. 3 Spatial distribution of LISA time paths for tourism efficiency and development level in Guangdong Province. The natural breakpoint method in the ArcGIS 10.2 software was used to classify the length and curvature of the LISA time paths of tourism efficiency and development level in Guangdong Province into four classes; the transfer direction of the LISA coordinates of each city was calculated.

Table 3 Transition probability matrix of Local Moran's I.

	Tourism efficiency				Tourism development level			
	HH _{t+1}	HL _{t+1}	LH _{t+1}	LL _{t+1}	HH _{t+1}	HL _{t+1}	LH _{t+1}	LL _{t+1}
HH _t	I (3,14.29)	III (5,23.8)	II (6,28.6)	IV (0,0)	I (2,9.52)	III (12,37.56)	II (5,18.69)	IV (0,0)
HL _t	II (0,0)	I (0,0)	III (0,0)	IV (9,42.86)	II (3,21.27)	I (6,0.65)	III ((5,11.32)	IV (0,0)
LH _t	IV (7,0.36)	I (12,35.11)	III (3,10.21)	IV (0,0)	IV (0,0)	I (8,21.6)	III (0,0)	IV (0,0)
LL _t	I (0,0)	II (0,0)	IV (0,0)	III (9,0.69)	I (18,58.27)	II (0,0)	IV (11,25.46)	III (0,0)

Spatial and temporal dynamic evolutionary characteristics of tourism efficiency and development level

LISA time path analysis. The Moran scatter plot of tourism efficiency and development levels in 2000, 2010, and 2020 simulates the exact locations of 21 cities in Guangdong Province. We calculated the length, curvature, and direction of the LISA time path for each city unit. This study analyzed the dynamic characteristics of local spatial structure, spatial dependence, directional fluctuation, and spatiotemporal dynamics of the spatial integration of tourism efficiency and development level in Guangdong Province. By using the natural breakpoint method in ArcGIS 10.2 software, the length, and curvature of the LISA time path of tourism efficiency and development level in Guangdong Province could be divided into four categories. The transfer direction of LISA coordinates for each city was calculated (see Fig. 3).

LISA time path curvature. The average LISA time path curvature for tourism efficiency was 10.424 (Fig. 3b); 12 cities showed less than the mean, accounting for 57.14% of the total. The highest LISA time path length was in Guangzhou City (27.925) and the lowest was in Meizhou City (3.246), showing a large difference.

The mean value of the LISA time path curvature for the tourism development level was 6.813 (Fig. 3e); 10 cities showed less than the mean value, accounting for 47.62% of the total. The local spatial structure of the tourism development level was slightly more volatile in the direction of dependence than tourism

efficiency. The path curvature was higher in the PRD region and lower in the peripheral regions. Shenzhen (19.309) and Zhuhai (11.076) had a higher LISA time path curvature, and Meizhou (1.250) had the lowest. The “W” shape of the aggregation of low values for the path curvature of the tourism development level and efficiency was similar, which may be caused by insufficient technical input. The dependence direction of the local spatial structure of the tourism efficiency and development level in Guangdong Province in 2020 was relatively stable. The latter was slightly more volatile than the former, whereas both had a similar change in the direction of spatial dependence.

LISA spatiotemporal leap analysis. The spatiotemporal leap analysis method was used to further describe the local spatial correlation type of the LISA coordinate points and the process of Moran scatter plot evolution among different local types (Table 3). There were 18 cities in which tourism efficiency experienced a spatiotemporal leap, accounting for 85.71% of the total. The local Moran's I is more active in transferring between types. The local regional structure of tourism efficiency was unstable, such that municipal units could easily change their relative positions. There were three type IV cities in which no spatiotemporal leap occurred, accounting for 14.29% of the total; the tourism efficiency of municipal units still had a certain transfer inertia. Five type III cities featured synergistic leaps, accounting for 23.81% of the total number of cities with leaps. The local spatial structure of tourism efficiency for municipal units was influenced more by

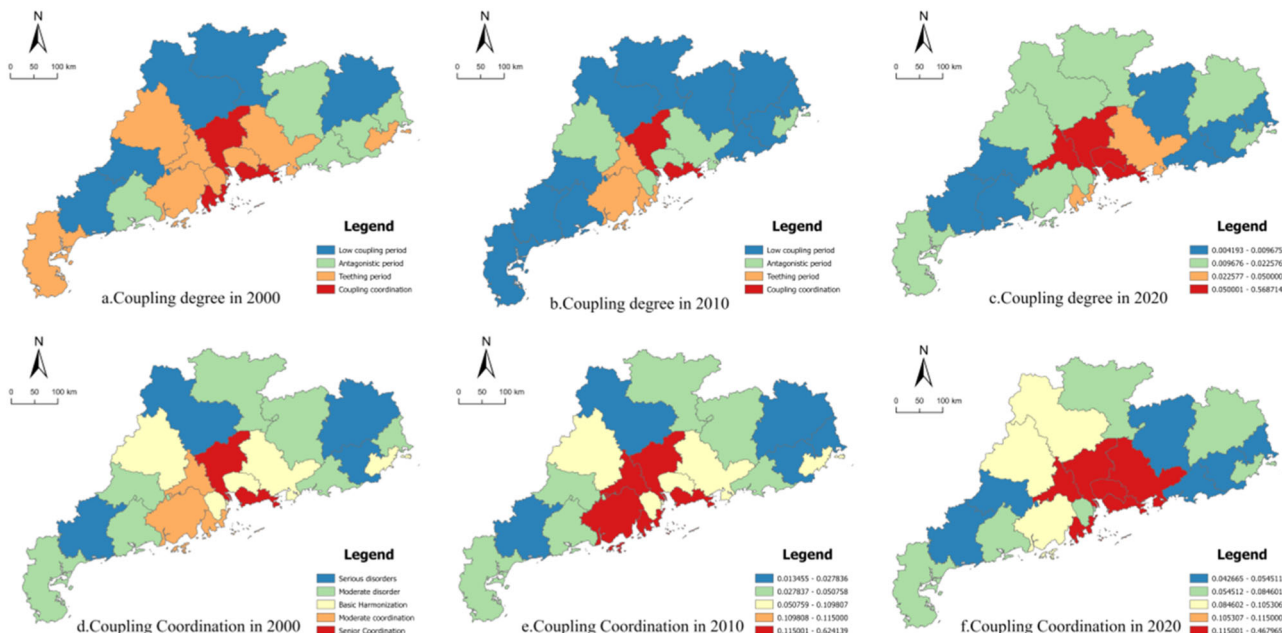


Fig. 4 Spatial distribution of the coupling degree and coordination coupling degree of the tourism efficiency and development level. The ArcGIS 10.2 software was used to plot the spatial distribution of the coupling degree in 2000, 2010, and 2020.

their own factors than the overflow of neighboring units. The number of type HH cities increased from three to five, with an increase in the overall agglomeration of cities with a higher tourism efficiency.

Fifteen cities showed spatiotemporal leaps in the tourism development level, accounting for 71.43% of the total. The local Moran's I transfer between types was small; there were only four types: $HL_t \rightarrow HH_{t+1}$ (37.56), $LL_t \rightarrow HH_{t+1}$ (11.32), $LL_t \rightarrow HL_{t+1}$ (21.6), and $LL_t \rightarrow LH_{t+1}$ (25.24). This shows that the local regional structure of the tourism development level in Guangdong Province is more stable, with certain path dependence or locking, i.e., it is more difficult for municipal units to change their relative positions. Six type IV cities did not have a spatial and temporal leap, accounting for 19.35% of the total; the inertia of the tourism development level transfer of municipal units was strong. Two type III cities showed collaborative leaps, accounting for 9.53% of the total number of cities with leaps; the independence of the tourism development level leap of municipal units was stronger. The number of type HH cities increased from two to four, and the overall agglomeration of cities with lower tourism development levels increased. The number of type LL cities decreased from four to two, and the dispersion of cities with a lower tourism development level increased.

Coupling and coordination relationship between tourism efficiency and development level

We measured the coupling coordination degree value from 2000 to 2020, referring to the relevant research results combined with our findings (Liao and Zhang, 2021). We divided the coupling coordination degree into five types: severe disorder, moderate disorder, basic coordination, moderate coordination, and high coordination, with 0.05, 0.1, 0.15, and 0.2 as the critical values, respectively. We mapped the spatial distribution of the coupling coordination degree for 2000, 2010, and 2020 (see Fig. 4).

The mean values of coupling coordination in Guangdong Province in 2000, 2010, and 2020 were 0.115, 0.136, and 0.159, respectively, gradually rising from severe dissonance to basic coordination. In 2000, the tourism efficiency and development level in most cities were in a state of severe overall dissonance; the

high-value areas of coupling coordination were scattered (Shenzhen, 0.458; Guangzhou, 0.609). In 2009, five cities were highly coordinated, rising by 150.00% from the two in 2000. In 2020, 6 cities reached the basic coordination stage, accounting for 25.58% of the total number of cities, rising by 20% from the 5 in 2009. The increase was mainly concentrated in the PRD region. Zero cities had medium coordination, and three cities had basic coordination, both of which have increased significantly. Among them, the spatial pattern of coupling and coordination degree changed significantly from 2001 to 2011, which was due to the significant instability in the initial stage of regional tourism development, strong spatial heterogeneity, and frequent and active changes in the scale and efficiency of tourism development. The development of regional tourism in Guangdong Province gradually matured from 2011 to 2020, with stable changes in the scale and efficiency of tourism development. The spatial pattern of coupling coordination tended to be stable; high coupling coordination regions tended to gather in space (Liao and Zhang, 2022).

The results show that the overall coupling degree coordination of the tourism efficiency and development level of Guangdong municipalities gradually improved from 2000 to 2020; most of the cities with poor coupling coordination gradually improved in the process of antagonism and friction, completing the leap from dysfunction to coordination. However, the coupling coordination degree of some regions with higher initial levels, represented by Guangzhou and Shenzhen, showed gradual or continuous regression, which is similar to their coupling degrees. The coupling coordination degree of the tourism efficiency and development level roughly coincided with the high-value area of the coupling degree, with similar spatial divergence characteristics. The time evolution of both had a certain correlation with local spatial heterogeneity and fluctuation, but the spread of the high-value area of the coupling coordination degree was gradual, slow, and substantial. The spread was wider and slower than that of the high-value area of the coupling degree. This indicates that the effect of the core city cluster construction, aiming to balance regional resource allocation, has not been fully revealed. The core city is still accelerating the gathering of production factors, such as population, capital, and technology. The city has not yet fully

absorbed the rapid increase in resources. The excessive gathering of resources inhibits the technological progress and tourism efficiency of the city and even limits the benign development of the surrounding areas. At the same time, the coupling coordination and degree of the tourism development level and efficiency had similar spatial differentiation characteristics. Their time evolution had some relevance, and local spatial heterogeneity and volatility were identified; however, the diffusion range of high-value areas of the coupling degree was wider and faster than that of the high-value areas of the coupling coordination. At present, the effectiveness of regional cooperation in tourism development in Guangdong Province is insufficient. The lack of synergy in urban clusters indicates that the core cities do not have enough driving force; therefore, we must accelerate the construction of core city clusters and regional collaboration to alleviate the serious degree of imbalance in the spatial distribution of core production factors. This would also promote the coordinated development of tourism efficiency and development level in the region by dispersing the technical, talent, and industrial advantages of core cities.

Conclusion and discussion

Conclusions. (1) The average tourism comprehensive efficiency in the Guangdong Province from 2000 to 2020 was distributed mainly in the PRD region and had a limited distribution in the eastern, western, and northern regions, with evident spatial differences and an overall fluctuating downward trend. Scale efficiency plays a supporting role in comprehensive efficiency, while technical efficiency has an influencing and constraining role. The overall tourism development level was at the medium scale. The scale of high-value areas was concentrated in the PRD region, indicating that the majority of cities have room for growth in terms of their tourism development level. Significant improvement in technological progress changes is the main factor in maintaining positive growth in tourism efficiency. However, when scale efficiency is more or less unchanged, but the overall comprehensive efficiency is in a fluctuating decline, the factor allocation is unreasonable. In this case, a low input-output conversion rate leads to poor tourism development. Tourism development faces an urgent need for transformation and upgrades.

(2) The tourism efficiency at the local spatial scale of Guangdong Province remains unstable, with a greater possibility of change in the municipal unit. The tourism development level at the local spatial scale is more stable than the tourism efficiency, and the relative location of cities is more difficult to change. Enhancing tourism efficiency by adjusting the tourism development level is feasible, but the effect would be limited. Factors such as the economic development level, tourism resource endowment, transportation service facilities, and macro policies all have an impact on the spatiotemporal evolution of the tourism development level and efficiency in Guangdong Province. However, each influencing factor has different driving forces on the spatiotemporal evolution of the tourism development level and efficiency in different periods and regions. The changes in the tourism development level and efficiency in Guangdong Province were the combined result of multiple factors. The local spatial structure of tourism efficiency and development level is influenced by neighboring units but more so by internal factors. Therefore, each city should further improve the subjective initiative of tourism development, find the key direction of their own misaligned development, and seek differentiated and synergistic development.

(3) Tourism efficiency, tourism development level, and coordination between the two have similar characteristics in both time and space. They collectively rise over time. Spatially, efficiency and development levels present a distribution characteristic of high values in the PRD region and low values in the

eastern, western, and northern regions of Guangdong. Cities with higher coordination have higher tourism efficiency and development levels, while cities with lower coordination have lower tourism efficiency and development levels. Therefore, there is a positive linear relationship between coordination and tourism efficiency and development level. When the degree of coordination is higher, the development of the tourism industry in the region is more efficient, reasonable, and healthy, and can also indicate a more developed tourism industry in the region.

(4) Although the tourism development scale of 21 cities in Guangdong Province has made marked progress, the spatial differences in tourism development efficiency are significant. The distribution of regional units with different scale attributes is relatively scattered, with evident polarization characteristics. This is due to the significant differences in the internal tourism development base; in contrast, it is due to the disharmony in regional internal development and cooperation. Therefore, we must strengthen the integration of regional tourism, build a tourism collaborative development circle, and improve the intensity and speed of the flow of regional tourism development factors from the central city areas to the peripheral areas in the process of regional tourism development. The surrounding areas could develop under the influence of the trickle-down effect and promote the coordinated development of different tourism regions. The spatiotemporal evolution of regional tourism development efficiency is highly variable and does not have evident cyclical characteristics. Therefore, fully understanding and leveraging the advantages of each development factor, seeking the optimal input of marginal tourism efficiency development factors and reasonable allocation of multiple factors, and improving the efficiency of regional tourism development is necessary (Cao et al., 2016; Li et al., 2021).

Discussion

(1) *Evaluation index selection:* The measurement of tourism quality can prioritize economic development or a resource- and environment-friendly orientation. Owing to the limited data on the research unit, this study followed the traditional evaluation indices of tourism efficiency and development level to measure tourism quality and obtain its spatial and temporal evolution and coupling coordination, thereby clarifying the regional tourism development path. In the era of high-quality tourism development, scale and efficiency are equally important. The comprehensive measurement of tourism quality from both a tourism efficiency and development level perspective deepens previous research. The selection of different evaluation indicators and results will vary; these should be further improved in subsequent studies to efficiently measure tourism quality. Such research should also consider the influence of multiple factors on tourism development quality, such as sustainability, transportation convenience, human aspects, and policy conditions (Liu et al., 2022; Yang et al., 2023). This will aid in building a systematic and comprehensive tourism quality evaluation system with more general significance.

(2) *Tourism efficiency and high-quality tourism development:* Research has found that the spatial differences in the coupling and coordination between tourism efficiency and high-quality tourism development in Guangdong Province are decreasing, but significant regional disparities remain. Therefore, cultivating regional growth poles and strengthening regional cooperation and exchanges are effective ways to narrow disparities. Specifically, Guangdong Province should take Guangzhou and Shenzhen as core growth poles, fully leveraging the leading role of the PRD in improving tourism efficiency and high-quality tourism development. By means of industrial transfer, factor flow, market co-construction, and deepening cooperation, the development of surrounding areas is radiated and driven.

On one hand, local governments need to deepen regional tourism cooperation, which requires that regions belonging to the same sector not be constrained by administrative boundaries when formulating policy guidelines, fully leveraging the radiative driving effect of central cities, promoting cross-regional cooperation and development, maximizing spatial interaction effectiveness, creating a community of interests, and achieving overall coordinated development of regional tourism are necessary. On the other hand, optimizing the proportion of investment factors is necessary. Each city adjusts the proportion of investment factors, such as funds, labor, infrastructure, transportation construction, and scenic area development, according to its own tourism industry characteristics, which helps to achieve efficient, coordinated, and sustainable development of the tourism industry.

(3) *Countermeasure analysis*: Based on the analysis of the spatiotemporal evolution characteristics and influencing factors of tourism efficiency, scale, and coupling coordination in the Guangdong Province, scientific and appropriate strategies are proposed for the four-level subgroups with different characteristics. For Level I subcluster cities, such as the PRD region, tourism efficiency and economic development are already in a self-organized state of benign accumulation. Based on the spatial spillover effect of high-value area tourism efficiency and the spatial agglomeration effect of economic development, they should radiate and drive the surrounding areas to improve their comprehensive development. For Level II subgroup cities, we should leverage our efforts and seize the opportunity to enter Level I subgroups. The analysis of influencing factors shows that economic factors have a greater impact on the overall level of coupling and coordination, driving tourism development with economic strength and achieving coupling and coordination between the two. For Level III subgroup cities, their economic development level is generally low, and the distance between them and high-value economic areas is gradually widening, making growth points that drive economic development from traditional industries difficult to find. However, the tourism industry is different from general traditional industries, and its low-value areas exhibit fluctuating development characteristics over time, which are not limited by the pattern of economic polarization development. It is elastic and is the most easily compensated industrial weakness of economically disadvantaged areas. Level III subcluster cities should take advantage of the policies of rural revitalization and global tourism to seek the possibility of driving coupled and coordinated development from the tourism industry, focusing on improving the scale efficiency of tourism while preventing the decrease in scale efficiency caused by blind and redundant tourism development. For the Level IV subgroup cities, their tourism efficiency and economic development level are imbalanced and always fluctuating at a low level. Therefore, the coupling development of tourism efficiency and development level should be considered to find the intersection between the two and exert the maximum influence of the interaction between tourism and the economy. The advantages of tourism development should be cleverly invested in the economy, supported by each other to achieve coupling, and promoted for the coordinated and healthy development of the two.

(4) *Coordinated regional development*: Guangdong Province tourism quality shows a clear regional divergence, being high in the PRD region and low in the eastern Guangdong, western Guangdong, and northern Guangdong regions. The tourism development foundation in the eastern Guangdong region is weak and needs to be flexible in learning from regions with advanced technology and experience to optimize the return on tourism investment. The momentum of the western Guangdong region's tourism development is insufficient. To fully exploit their own resource potential, this region should stimulate tourism development vitality. The PRD region has limited room for progress. To accelerate industrial

restructuring and technological innovation, this region should transfer some of the advantages of its resources to other regions. According to the requirements for high-quality development of the tourism industry, the Guangdong Province should optimize the total amount and proportion of tourism input factors based on the characteristics of its tourism industry development and the current situation of tourism input-output in order to avoid excessive investment redundancy. The protection of forest parks, wetlands, and nature reserves must be strengthened in the process of regional development, as well as continuously improving the quality of the ecological environment and playing a positive role in improving tourism efficiency. The deep integration of tourism with the primary, secondary, and tertiary industries must be continuously promoted to innovate tourism formats through "tourism+" and "+tourism," and to enrich the supply of high-quality tourism products. Considering the current situation and differences in tourism development in different cities, policies should be implemented accordingly in order to improve the overall tourism efficiency of the region.

Data availability

The original contributions presented in the study are included in the article/(Supporting Materials S1. Dataset), further inquiries can be directed to the corresponding author/s.

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References

- Bacos IB, Gabor MR (2021) Tourism economy mountain tourism: quantitative analysis of winter destinations in Romania. *Economics* 9(1):1985–1999
- Bi DD, Wang K, Wang LJ et al. (2018) Research on industrial eco-efficiency and spatio-temporal transition characteristics of the Yangtze River Delta. *Econ Geogr* 38(1):166–173
- Cao FD, Huang ZF, Jin C et al. (2016) Chinese national scenic areas' tourism efficiency: multi-scale fluctuation, prediction and optimization. *Asia Pac J Tour Res* 21(5):570–595
- Cao FD, Huang ZF, Yu FL et al. (2014) The spatial evolution of travel efficiency of China's national scenic areas and its driving mechanism. *Geogr Res* 33(6):1151–1166
- Dritsakis N (2012) Tourism development and economic growth in seven Mediterranean countries: a panel data approach. *Tour Econ* 18(4):801–816
- Fang SM, Huang Y (2020) Spatio-temporal evolutions and coordination of tourism efficiency and scale in the Yangtze River Economic Belt. *Acta Geogr Sin* 75(8):1757–1772
- Han J (2018) Carrying capacity of low carbon tourism environment in coastal areas from the perspective of ecological efficiency. *J Coast Res* 83(5):199–203
- He ZL, Wang SM (2020) Spatial-temporal evolution of China's tourism resource conversion efficiency and its impact mechanism. *China Popul Resour Environ* 30(11):185–193
- Li R, Guo Q, Wu D et al. (2014) Spatial characteristics of development efficiency for urban tourism in eastern China: a case study of six coastal urban agglomerations. *J Geogr Sci* 24(6):1175–1197
- Li SK, Tsang CK, Lee SK (2021) Sustainable development of the China tourism sector: implications from technical and scale efficiency measurements. *Chin Econ* 54(4):262–271
- Li WB, Zhang L, Guo RL (2020) The measurement of tourism environmental pollution and tourism efficiency in Western China. *J Coast Res* 104(s1):657–671
- Liao ZJ, Zhang LJ, Wang XF (2022) Spatial distribution characteristics and accessibility analysis of beautiful leisure villages in China. *PLoS ONE* 17(10):1–15
- Liao ZJ, Zhang LJ (2022) Spatial distribution characteristics and accessibility analysis of characteristic towns in Guangdong Province based on Ripley's K function. *J Math* 10(4):1–14
- Liao ZJ, Zhang LJ (2021) Spatial distribution evolution and accessibility of A-level scenic spots in Guangdong Province from the perspective of quantitative geography. *PLoS ONE* 16(11):1–18
- Liu QF, Song JP, Dai TQ et al. (2022) Spatial network structure of China's provincial-scale tourism eco-efficiency: a social network analysis. *Energies* 15(4):1–16

- Liu ZL, Lu CP, Mao JH et al. (2021) Spatial-temporal heterogeneity and the related influencing factors of tourism efficiency in China. *Sustainability* 13(11):1052–1079
- Ma XL, Bao JG (2009) Study on the evolution of Chinese primary cities' tourism efficiency influence factors. *Econ Geogr* 29(7):1203–1208
- Massidda C, Etzo I (2012) The determinants of Italian domestic tourism: a panel data analysis. *Tour Manag* 33(3):603–610
- Munro J, Kobryn H, Palmer D et al. (2019) Charting the coast: spatial planning for tourism using public participation GIS. *Current Issues Tour* 22(4):486–504
- Nina B (2020) Regional development of rural tourism: the case of the Gorska Hrvatska region. *Nae Gospod/Our Econ* 66(2):28–41
- Pablo JC, Marcelino S, Juan IP (2015) Does tourism growth influence economic development? *J Travel Res* 54(2):206–221
- Pan QL, Song YQ, Chen L et al. (2021) The spatial pattern and influencing factors of county-scale tourism efficiency in Shaanxi province. *J Nat Resour* 36(4):866–878
- Purnomo S, Rahayu ES, Riani AL et al. (2020) Empowerment model for sustainable tourism village in an emerging country. *J Asian Finance Econ Bus* 7(2):261–270
- Qiao GT, Chen F, Wang N et al. (2023) Spatio-temporal evolution analysis of the coupling situation of the economic-social-ecological system in Guangdong. *J Geogr Sci* 30(3):32406–32426
- Ramona C, Ciprian R, Simona C et al. (2017) Management of a tourist village establishment in mountainous area through analysis of costs and incomes. *Sustainability* 9(6):875
- Rey SJ, Janikas MV (2006) STARS: space-time analysis of regional systems. *Geogr Anal* 38(1):67–86
- Seetaram N (2012) Immigration and international inbound tourism: empirical evidence from Australia. *Tour Manag* 33(6):1535–1543
- Sun PP (2019) Is the influence of Chinese local government act on tourism efficiency positive? *China Finance Econ Rev* 8(2):88–109
- Tang R (2021) Trade facilitation promoted the inbound tourism efficiency in Japan. *Tour Manag Perspect* 38:899–912
- Wang C, Tang N (2018) Spatio-temporal characteristics and evolution of rural production-living-ecological space function coupling coordination in Chongqing Municipality. *Geogr Res* 37(6):1100–1114
- Wang J, Xu JH, Xia JC (2017) Study on the spatial correlation structure of China's tourism economic and its effect: based on social network analysis. *Tour Trib* 32(7):15–26
- Wang K, Huang ZF, Cao FD et al. (2016) Spatial pattern evolution of urban tourism performance and its influence factors in Pan-Yangtze River Delta. *J Nat Resour* 31(7):1149–1163
- Wang SM, Chu YJ, Guo AX et al. (2020) Study on high quality development of tourism economy in 18 key provinces along the one belt and one road initiative: based on the measurement of tourism resource conversion efficiency. *Sci Geogr Sin* 40(9):1505–1512
- Wang SM, Guo YZ (2018) Construction and empirical study of tourism poverty alleviation efficiency evaluation model: empirical evidence from China. *Soc Sci* 254:88–97
- Wang YB, Wang MZ, Li KM et al. (2021) Analysis of the relationships between tourism efficiency and transport accessibility: a case study in Hubei province of China. *Sustainability* 13(15):99–124
- Wang ZF, Liu QF, Xu JH et al. (2020) Evolution characteristics of the spatial network structure of tourism efficiency in China: a province-level analysis. *J Destin Mark Manag* 18:559–583
- Xu D, Huang ZF, Hu XH et al. (2018) The spatial pattern evolution and its influencing factors of county-scale tourism efficiency in Zhejiang province. *Econ Geogr* 38(5):197–207
- Yang YW, Zhang CX, Qin ZW et al. (2023) The spatial-temporal pattern evolution and influencing factors of county-scale tourism efficiency in Xinjiang, China. *Open Geosci* 14(1):1547–1561
- Ye XY, Carroll MC (2011) Exploratory space-time analysis of local economic development. *Appl Geogr* 31(3):1049–1058
- Zhang JH, Zhang J, Li N et al. (2005) An analysis on spatial field effect of domestic tourist flows in China. *Geogr Res* 24(2):293–303
- Zhang LJ, Marzuki A, Liao ZJ et al. (2023) Spatial and temporal evolution of Guangdong tourism economic network structure from the perspective of social networks. *Heliyon* 9(7):1–16
- Zhang W, Zhou YY, Hu GW (2013) Coupling mechanism and space-time coordination of new-approach urbanization, new-approach industrialization and service industry modernization in megacity behemoths: a case study of ten cities in China. *Sci Geogr Sin* 33(5):562–569
- Zhou HT, Zhang YH, Ning XL et al. (2021) Spatial-temporal differentiation characteristics of A-class tourist attractions in Inner Mongolia. *J Arid Land Resour Environ* 35(12):202–207

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Author contributions

Conceptualization, ZL; data curation, LZ; formal analysis, ZL, writing—original draft, LZ and ZL; software, ZL; writing—review and editing, LZ, AM, and ZL. All authors have read and agreed to the published version of the manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

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Additional information

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