International Journal for Housing Science and Its Applications
Publish August 4, 2025. Volume 46, Issue 3 Pages 2371-2381

https://doi.org/10.70517/ijhsa463198

Dynamic study on the influencing factors and spatial and temporal evolution of cross-travel integration in Guangxi based on multiple regression computational analysis

Yun Zhao[1,2], Peilin Lang[1] and Hong Wang[3,*]
[1] College of Tourism Management, Guilin Institute of Tourism, Guilin, Guangxi, 541006, China
[2] College of Tourism and Service, Nankai University, Tianjin, 300350, China
[3] Guizhou Provincial Tourism Planning and Design Institute, Guiyang, Guizhou, 556099, China
Corresponding authors: (e-mail: gl5878@126.com).

Abstract The integrated development of transportation and tourism is a strategic choice to cope with the diversified needs of tourists, and also an important way to transform and upgrade the tourism industry in the new development period. In this paper, 14 prefecture-level cities in Guangxi are taken as research samples. Based on the comprehensive development level of transportation industry and tourism industry in Guangxi, a comprehensive evaluation index system of transportation industry and tourism industry in Guangxi is established. By collecting and analyzing panel data from 2010 to 2022, Coupled coordination degree analysis and exploratory spatial data analysis are used to evaluate and analyze the development level of transportation and tourism integration in Guangxi, measure the comprehensive level of transportation and tourism industry in Guangxi and their integrated development status, and analyze the spatio-temporal evolution characteristics and influencing factors of transportation and tourism integration in Guangxi based on the integrated development status of prefecture-level cities.

Index Terms Guangxi, transportation integration, time evolution and influencing factors

I. Introduction

In recent years, the contribution of tourism to national economic growth has been increasing [1]. Transportation is the basic support and prerequisite for the tourism industry to “go out”, and the deep development of the tourism industry can not be separated from the support of transportation, which also guides the precise application of transportation and vigorous development [2]-[4]. Therefore, the deep integration of transportation and tourism industry, synergistic development, is to adapt to the new situation of transportation planning in the information age, tourism development of new business, and to achieve good and fast economic development of the important hand, but also to promote the supply-side structural reform is an effective way [5]-[8]. With the accelerated growth of the transportation and tourism industries, the integration and development of the two has become a topic of great concern.

Transportation plays a crucial role in supporting and promoting the development of tourism, which must be generated through a reliable and convenient transportation system in order to generate effective supply [9], [10]. As an important part of comprehensive transportation, highway transportation has the significant advantages of mobility and flexibility, convenient and direct access, and high speed, which can effectively solve the problem of “last mile” access to tourist attractions, and has an irreplaceable role in promoting the development of regional tourism travel [11]-[14]. Similarly, tourism can promote the improvement of transportation infrastructure and the expansion of transportation network [15]. In order to understand the interaction and influence of transportation and tourism, it is necessary to analyze the influencing factors and evolutionary path of the integration relationship between transportation and tourism to enrich the existing research.

This paper innovatively constructs a three-dimensional analytical framework of “process-pattern-mechanism”: firstly, the improved entropy-weighted TOPSIS method is used to overcome the problem of indicator covariance; secondly, the standard deviation ellipse and hot and cold spots analysis reveal the spatial evolution trajectory; finally, geodetectors are used to analyze the interaction intensity of natural and economic factors. The study breaks through the limitation of the traditional measurement model that ignores the spatial effect, provides methodological innovation for the synergistic development of industries in the western complex terrain area, and at the same time, provides scientific basis for the evaluation of the implementation effect of the Fourteenth Five-Year Plan for Comprehensive Transportation Development in Guangxi.

II. Study design

II. A. Construction of the indicator system

Under the premise of following the principle of indicator selection, the comprehensive evaluation index system of Guangxi's transportation industry and tourism industry is constructed by reading relevant literature, fully combining the existing research results and the actual situation of Guangxi's tourism industry and transportation industry, drawing on the existing evaluation index system, and reviewing the statistical indexes of the National Statistical Yearbook (Table 1).

Table 1: Comprehensive evaluation index system of Guangxi transportation industry and tourism industry

System	Primary indicators	Secondary indicators	Units
Tourism system	Tourism industry scale	Total number of inbound tourists	People
		Total number of domestic tourists	Thousands of people
	Tourism industry benefits	Foreign exchange income from international tourism	Billions of dollars
		Total domestic tourism revenue	100 million
		Total tourism revenue	100 million
	Tourism reception capacity	Number of star hotels	Individual
		Total number of travel agencies	Individual
		Tourism management department	Individual
Traffic system	Infrastructure construction	Length of ordinary roads	Kilometer
		Grade highway mileage	Kilometer
	Traffic service	Passenger traffic by road	Thousands of people

II. B. Modeling

II. B. 1) Coupling coordination evaluation model

In this paper, when exploring the coupling and coordination relationship between the tourism industry and the transportation industry, we draw on the theoretical framework of the concept of coupling and the coupling coefficient model in physics, and establish the coupling degree model of the two industries, tourism and transportation, to quantify the degree of coupling of these two industries:

$$C = 2 \times \left[\frac{U_1 \cdot U_2}{(U_1 + U_2)^2} \right]^{\frac{1}{2}} \tag{1}$$

where: C represents the degree of coupling of the two industries; U_1 and U_2 represent the comprehensive evaluation index of the two industries respectively. In addition, the coupled synergy model established to objectively reflect the degree of synergistic development of the two industries, taking into account the different states of the respective development levels of the two industries, in order to ensure the accuracy of the research results, in order to ensure the accuracy and objectivity of the research:

$$D(x,y) = \sqrt{C \times T} \tag{2}$$

D and T are the coupling coordination degree and comprehensive coordination index of the two industries, respectively, where T is the contribution of the overall development level of the transportation industry and tourism industry to the degree of coordination; and α and β are taken to be 0.5 due to the same importance of the two systems.

II. B. 2) Comprehensive development level evaluation model

In order to better study the coupling coordination degree of tourism and transportation systems, this paper adopts the comprehensive development level evaluation model to explore the comprehensive development status of the two systems.

First of all, in order to overcome the influence of factors such as size and dimension on the raw data, equation (3) is used to standardize the raw data. In this function formula, χ_{ij} is the original value of the data, χ'_{ij} is the value resulting from the normalization process; $\chi_{j\max}$ is the maximum value in the data of this indicator, $\chi_{j\min}$ is the minimum value in the data of this indicator.

$$\chi'_{ij} = \frac{\chi_{ij} - \chi_{j\min}}{\chi_{j\max} - \chi_{j\min}} \tag{3}$$

Second, the coefficient of variation method is used to calculate the indicators and obtain the corresponding weights of the indicators. In the operation process, the coefficient of variation is first calculated using equation (4), where v_i and σ_i are the coefficient of variation and standard deviation of the i th indicator, respectively; and $\overline{x_1}$ is the average value of the i th indicator. Then, the obtained v_i is normalized using equation (5) to obtain the indicator weights.

$$v_i = \frac{\sigma_i}{\overline{x_1}} \tag{4}$$

$$\omega_j = \frac{v_i}{\sum_{j=1}^{m} v_i} \tag{5}$$

Finally, the linear weighting method was applied to calculate the combined development level of the transportation industry and tourism industry, which was calculated by the formula:

$$U_i = \sum_{i=1}^{m} \omega_{ij} \chi'_{ij} \tag{6}$$

II. B. 3) Classification of coupling harmonization level

In order to more intuitively reflect the changes in the degree and level of the coupled and coordinated development of the transportation and tourism industries, the coupled and coordinated degree of the two industries is graded (Table 2).

Table 2: Coupling coordination degree classification standard

Coupling coordination degree D value range	Coordinate levels	Degree of coupling and coordination	Range of coupling coordination D value	Coordinate levels	Degree of coupling and coordination
[0.0~0.1)	1	Extreme dislocation	[0.5~0.6)	6	Barely manageable
[0.1~0.2)	2	major maladjustment	[0.6~0.7)	7	Primary coordination
[0.2~0.3)	3	Moderate disorientation	[0.7~0.8)	8	Intermediate coordination
[0.3~0.4)	4	Mildly disordered	[0.8~0.9)	9	Good coordination
[0.4~0.5)	5	Near to disorder	[0.9~1.0]	10	Quality coordination

II. C.Data sources

This paper selects the relevant index data of Guangxi's transportation industry and tourism industry from 2010 to 2022 for research. The raw data used are mainly from Guangxi Statistical Yearbook (2011-2023), China Statistical Yearbook (2011-2023), as well as Statistical Yearbook (2011-2023) and Statistical Bulletin of National Economic and Social Development (2010-2022) of 14 prefectural-level cities.

III. Results and analysis

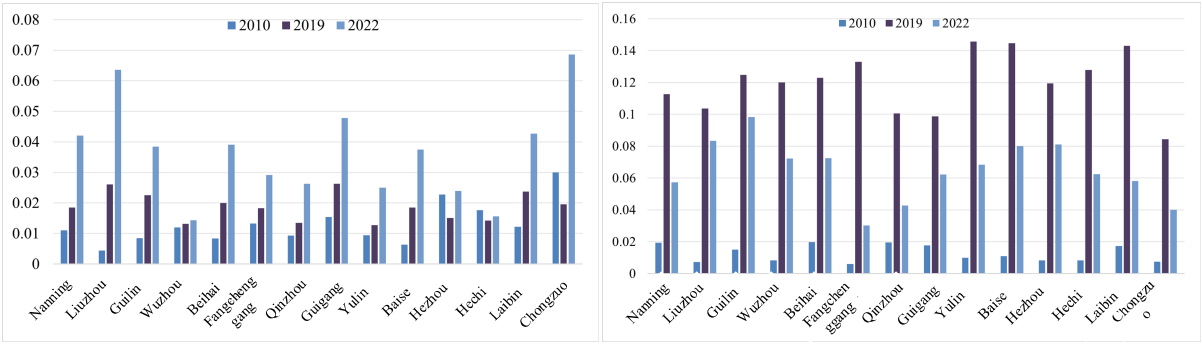
It can be found through the resulting data that the coupling and coordination degree of transportation industry and tourism industry in each city increased year by year during 2010-2019, and the coupling and coordination degree of each city declined during 2019-2022, which is due to the great impact of the Xin Guan epidemic on Guangxi's tourism industry since the end of 2019, which in turn affects the development of the integration of transportation and tourism. Therefore, in conducting the subsequent data analysis, this paper will select the three years of 2010, 2019, and 2022 as representative for analysis (Table 3).

III. A. Characterization of the integrated level of transport and tourism

The comprehensive development level of transportation industry and tourism industry of each prefecture-level city in Guangxi from 2010 to 2022 was derived respectively after analyzing the data by entropy weight TopSIS method. The comprehensive level of transportation and the comprehensive level of tourism of each city in 2010, 2019 and 2022 were selected for characterization (Figure 1).

Table 3: Coupling coordination degree D of transportation industry and tourism industry in Guangxi from 2010 to 2022

	2010	2011	2012	2013	2014	2015	2016
Nanning City	0.204	0.397	0.478	0.451	0.565	0.614	0.648
Liuzhou City	0.139	0.278	0.409	0.433	0.495	0.574	0.628
Guilin City	0.183	0.289	0.372	0.435	0.443	0.445	0.519
Wuzhou City	0.168	0.368	0.401	0.554	0.571	0.627	0.667
Beihai City	0.245	0.372	0.404	0.474	0.448	0.486	0.587
Fangchenggang City	0.154	0.317	0.38	0.518	0.466	0.502	0.532
Qinzhou city	0.21	0.378	0.458	0.468	0.395	0.429	0.514
Guigang City	0.216	0.312	0.439	0.528	0.465	0.569	0.601
Yulin City	0.186	0.276	0.334	0.491	0.447	0.529	0.585
Baise City	0.174	0.245	0.349	0.528	0.415	0.394	0.518
Hezhou city	0.209	0.276	0.423	0.514	0.385	0.542	0.471
Hechi City	0.181	0.422	0.51	0.527	0.61	0.65	0.695
Laibin City	0.206	0.373	0.377	0.453	0.47	0.539	0.565
Chongzuo	0.189	0.321	0.399	0.428	0.434	0.45	0.568
	2017	2018	2019	2020	2021	2022	-
Nanning City	0.687	0.774	0.815	0.565	0.554	0.408	-
Liuzhou City	0.681	0.671	0.784	0.545	0.546	0.493	-
Guilin City	0.628	0.742	0.844	0.561	0.486	0.476	-
Wuzhou City	0.719	0.817	0.859	0.599	0.613	0.463	-
Beihai City	0.568	0.675	0.867	0.563	0.59	0.414	-
Fangchenggang City	0.726	0.786	0.853	0.606	0.453	0.276	-
Qinzhou city	0.578	0.504	0.614	0.366	0.344	0.305	-
Guigang City	0.637	0.635	0.771	0.565	0.553	0.413	-
Yulin City	0.746	0.762	0.871	0.503	0.433	0.443	-
Baise City	0.52	0.736	0.723	0.513	0.467	0.474	-
Hezhou city	0.516	0.703	0.796	0.636	0.528	0.469	-
Hechi City	0.74	0.815	0.886	0.582	0.477	0.445	-
Laibin City	0.623	0.676	0.851	0.55	0.353	0.454	-
Chongzuo	0.624	0.718	0.632	0.456	0.437	0.427	-



(a) Comprehensive development level of transportation industry

(b) Comprehensive development level of tourism industry

Figure 1: Comparison of the comprehensive level of transportation industry and tourism industry in Guangxi cities from 2010 to 2022

The cities' comprehensive level of transportation industry was improved during the period of 2010-2022 through the extreme difference, in which the city with the largest extreme difference in the comprehensive level of transportation industry is 4.99 times of the smallest city, and the difference in the comprehensive level of

transportation industry is obvious. Some cities have rapid development of the comprehensive level of transportation industry during 2010-2022, among which Liuzhou city has faster growth and the best development trend of the comprehensive level of transportation industry, followed by Chongzuo, Guigang, Beihai, Laibin, Baise, Nanning and Guilin. This is determined to build a “national forefront, leading in the west” of Guangxi “transportation province” has an inseparable relationship.

Although the development of tourism industry in Guangxi cities in 2019-2022 by the epidemic impact of the comprehensive level of tourism industry in each city has produced a certain decline, but it can not be ignored is that the tourism industry in each city in 2010-2019 have rapid development, and the overall development of tourism industry is relatively balanced. The data show that the average value of the 2010-2022 average value of the top 2 municipalities of the tourism industry comprehensive water average value and the sum of the average value of the last 2 municipalities is 1.22 times the sum of the average value of the standard deviation value of 0.003, the gap between the level of the tourism industry in each city is relatively small. Among them, Yulin and Baise have the most prominent development, followed by Fangchenggang, Laibin and Hechi.

III. B. Analysis of the time-series evolution of the level of cross-travel integration

Through the coupling coordination degree of transportation industry and tourism industry in Guangxi cities from 2010 to 2022, the calculation and collation of its mean value, coefficient of variation, and extreme deviation distribution are shown in Figure 2. Although the mean value of the degree of coordination of each city produced a decline after 2019 due to the impact of the epidemic, in general, from 0.19 in 2010 to 0.43 in 2022, there is a general increase, with an increase of 223.72% during the period. The stage at which the mean value of coordination is at climbs from severe dislocation to intermediate coordination, which shows that the development of transportation and tourism integration has been successful and gratifying; although it gradually declines to the verge of dislocation after 2019, the downward trend has begun to slow down rapidly and is under control, and with the restoration and improvement of the tourism industry and the further development of the transportation industry, the restoration is just around the corner. Although the coefficient of variation and the extreme difference are in a fluctuating state, both of them are in an upward trend as a whole. The coefficient of variation is not obvious, which shows that the absolute regional differences in the degree of coordination between the two types of industries are not obvious; the extreme difference is more obvious, which shows that the relative differences between the cities are gradually becoming bigger.

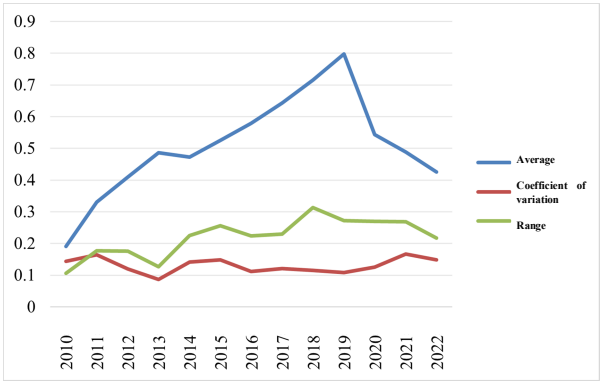


Figure 2: Time series variation characteristics of the coupling coordination degree of transportation and tourism industry in Guangxi cities from 2010 to 2022

Collation of the 2010-2022 coupling coordination degree level of each city to derive the 2010-2022 transportation industry and tourism industry coordination degree level of the number of statistical tables (Table 4), in order to make the data changes more clear and concise, the table does not have the coordination of the stage of the table in order to leave the white treatment:

As can be seen from Table 4, since 2010, the coordination of Guangxi's transportation industry and tourism industry has been continuously improving, showing a good development trend. During the study period, the coordination of transportation industry and tourism industry fluctuates and fluctuates in each city, and although the coordination grade of transportation industry and tourism industry in each city declined after 2019, not only did some of the cities enter the good coordination stage during 2018-2019, but also compared to 2010, the number of cities with serious dislocation was reduced from 8 to 0. Except for Fangchenggang City, which is in the moderate dislocation stage, and Qinzhou City, which is in the mild dislocation stage, the remaining 12 cities are on the verge

of the dissonance stage. Guangxi's transportation industry and tourism industry in general are in the optimization development stage of the transition from dislocation to dislocation-coordination, presenting an upward development trend.

Table 4: Distribution of coordination degree between transportation industry and tourism industry in Guangxi cities from 2010 to 2022

Coordination phase	Years												
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Major maladjustment	8												
Moderate disorientation	6	5											1
Mildly disordered		8	6		2	1					1	2	1
Near to disorder		1	7	8	9	4	1				1	6	12
Barely manageable			1	6	2	6	8	4	1		10	5	
Primary coordination					1	3	5	6	4	2	2	1	
Intermediate coordination								4	7	4			
Good coordination									2	8			

By analyzing the differences between transportation industry and tourism industry in the comprehensive level, the type of local integration and coordination degree can be analyzed. The lagging type of tourism industry development means that the comprehensive level of transportation industry is greater than the comprehensive level of tourism industry, and the lagging type of transportation industry development means that the comprehensive level of transportation industry is lower than the comprehensive level of tourism industry, and it is the synchronous development type when the development level between the two is roughly equal.During the period of 2010-2022, the comprehensive level of Guangxi's tourism industry is significantly better than that of the transportation industry in all cities. Among them, 10 cities are always lagging in the development of transportation industry, three cities of Fangchenggang, Hechi and Hezhou are gradually changing from lagging in the development of tourism industry to lagging in the development of transportation industry, and Chongzuo, though still in the lagging in the development of tourism industry, has changed to lagging in the development of transportation industry during the period of 2013-2022. It can be seen that Guangxi's transportation industry wants to realize the synchronous and coordinated development of the tourism industry, there is still room for progress, and still need to continue to promote.

III. C. Characteristics of spatial differentiation in the level of cross-travel integration

III. C. 1) Characterization of regional spatial differences

According to the geographic location, people's habits, distribution of tourist attractions and economic level, Guangxi is divided into five regions: Guilin City, Hezhou City, composed of Gui North; Nanning City, Laibin City, Liuzhou City, Chongzuo City, composed of Guizhong; Yulin City, Wuzhou City, Guigang City, composed of Gui East; Beihai City, Qinzhou City, Fangchenggang City, composed of Gui South, as well as by the city of Baise, Hechi, composed of Gui West.

From the regional differences in the degree of coordination of each city in Figure 3, it can be seen that the overall trend of the level of coordination of each region in Guangxi during the period of 2010-2022 is “GuiNorth > GuiWest > GuiZhong > GuiDong > GuiNan”, which not only reflects the differences in coordinated development of the various regions, but also reveals the different performance of the level of development of the regional tourism economy in them. Specifically, the northern part of Gui is good at utilizing local natural and cultural resources and driving the overall improvement of the local area through the development of the tourism industry, showing a leading edge in the integration of the transportation industry and the tourism industry; the level of industrial integration in the eastern and central parts of Gui, despite experiencing certain fluctuations, is generally maintaining a positive trend and is gradually realizing the balanced development of the integration of the transportation and tourism industry; the western part of the industrial integration in Gui The level of industrial integration in the western region of Guangxi is also improving all the way. In general, the level of coordination among regions in Guangxi has been improving under the unremitting efforts of local governments to promote economic restructuring and industrial upgrading. The internal difference of each region is “Guinan>Western Gui>Central Gui>Eastern Gui>Northern Gui”, in which the imbalance of the integrated development of communication and tourism industry in the southern region of Guangxi has become more and more significant, and the problem of polarization has become more and more prominent, which is related to the fact that the Silver Beach of Beihai City and other tourism products are becoming the choices of more and more tourists, whereas Fangchenggang and Qinzhou City lack the domestic and international famous tourism

products. Tourism products. However, with the development of tourism in recent years in western Gui, the balance of the region has been greatly improved, which is inextricably linked to Baise's exploration of red tourism.

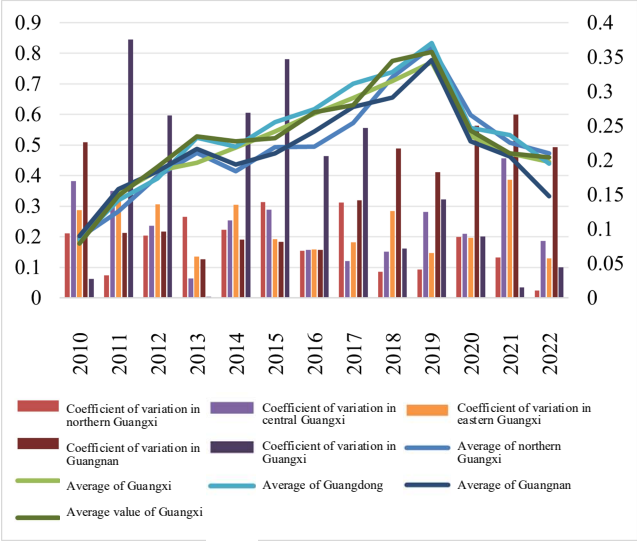


Figure 3: Regional differences of coordination degree among cities in Guangxi from 2010 to 2022

From Fig. 4, the spatial level difference of the coupling coordination degree of transportation industry and tourism industry of Guangxi cities from 2010 to 2022 is relatively small. 2010, Guangxi cities were in the stage of severe or moderate dissonance; in 2019, not only Fangchenggang City and Hezhou City have reached the stage of primary coordination, except for Qinzhou City, which is still in the stage of mild dissonance, the rest of the cities are in the stage of near-dissonance or barely coordinated. By 2022, all cities in Guangxi will be in the range of moderate dissonance to near-dissonance, and although most of the cities have declined compared to 2019, the overall level of coordination is more uniform. It is still important to note that Qinzhou is slightly independent within the Guangxi region, with weak linkages to changes in neighboring regions, and attention should be paid to strengthening linkages between Qinzhou and other regions.

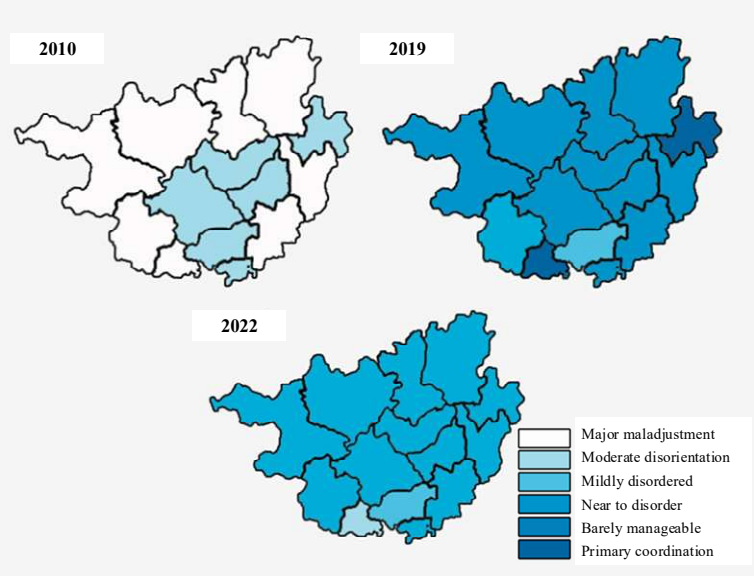


Figure 4: Spatial changes of coordination degree in Guangxi cities in 2010,2019 and 2022

III. C. 2) Characterization of the evolution of regional spatial patterns

Considering the number of research units and the spatial distribution pattern, this study is based on the specific position of each city in Guangxi in the geospatial space, and derives the migration path of the center of gravity of

the coordination degree of each city in Guangxi and the change of the long and short axes of the standard deviation ellipse by constructing the statistical relationship of the level of integration, in order to depict the spatial distribution characteristics of each city in Guangxi, and to carry out the analysis of the spatial pattern of the level of integration of the transportation and tourism industries in Guangxi.

As can be seen from Figure 5, the center of gravity of the degree of coordination of the integration of the transportation industry and tourism industry in each city gradually deviated from the equilibrium point in the northwest direction in 2010-2014, with a displacement of 11.47 km, and the center of gravity shifted to the east direction by another 8.9 km in 2014-2015, and then shifted to the west direction again by 8.95 in 2015-2018 In 2014-2015, the center of gravity moves 8.9km to the east, 8.95km to the west again in 2015-2018, and 12km to the northeast in 2018-2022. Although the center of gravity of the degree of coordination of cross-traffic and tourism integration moves frequently, it fluctuates mainly between Nanning and Guilin, and ultimately, the overall trend is to move to the northeast. This is because Guangxi's “Twelfth Five-Year Plan” is determined to go all out to promote the construction of international channels out of the sea and out of the province and out of the border, and to form a 2-hour Guangxi Beibu Gulf Economic Circle centered on Nanning and accessible to cities and ports in the Beibu Gulf Economic Zone, so the center of gravity of traffic and tourism industry integration in the early period is more biased towards Nanning City side. And with Guilin is committed to building a modern international tourism city, historical and cultural city, ecological landscape city, accelerate the construction of world-class tourist destinations and regional tourism distribution center, Guilin and its surrounding areas constitute a large Guilin tourism circle gradually become the center of gravity of the degree of coordination of the traffic and tourism industry integration.

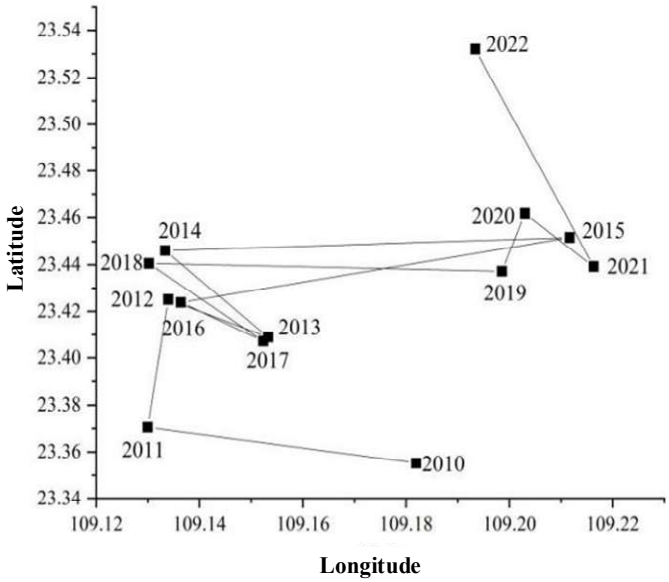


Figure 5: Shift path of coordination center of gravity in Guangxi cities from 2010 to 2022

As can be seen in Figure 6, the short half-axis of the standard deviation ellipse of the degree of coordination of Guangxi cities is significantly longer than the long half-axis from 2010 to 2022, and the gap gradually increases with the passage of time, which indicates that the degree of dispersion of the data distribution shows a trend of gradual increase. The value of the short axis grows from 164.08 in 2010 to 166.58 in 2022, showing a clear trend of data distribution dispersion in the northeast-southwest direction. The long semiaxis increases from 208 in 2010 to 213.98 in 2022.This change may be due to economic development or other factors resulting in geographical expansion or market competition. The standard deviation ellipse flatness decreases from 0.789 in 2010 to 0.778 in 2022, which indicates that the two ends of the ellipse are getting closer to the center, i.e., the degree of dispersion is decreasing, which means that the integration development of transportation and tourism industry in each city is being reduced by the spatial spillover effect of the neighboring municipalities, and it should be improved in time.

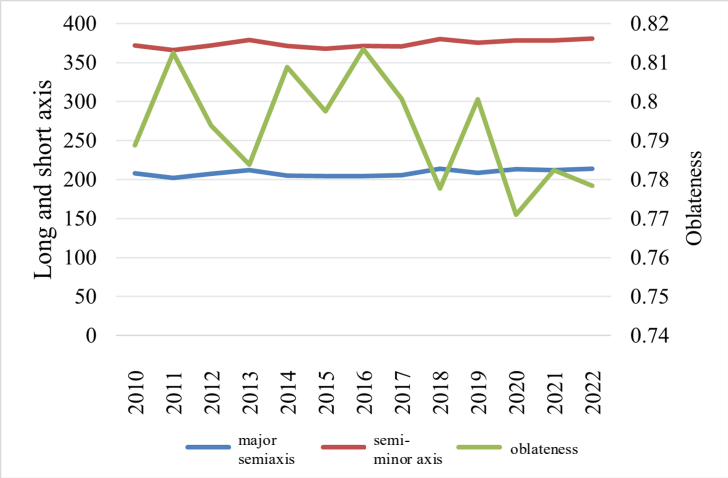


Figure 6: The variation of the long and short axes of the standard deviation ellipse of coordination degree in Guangxi cities from 2010 to 2022

III. D. Analysis of influencing factors

In order to deeply analyze the complex interaction between Guangxi's transportation industry and tourism industry, and how these factors influence each other and act on different aspects of tourism development, this study adopts an exploratory factor analysis method.

This method analyzes infrastructure construction indicators and transportation service indicators in combination with the comprehensive level of tourism industry development to reveal the intensity of the role of changes in transportation facilities and changes in the level of transportation services in enhancing the attractiveness of tourism, as well as the impact on promoting the development of the tourism industry; and analyzes the three indicators of the scale of the tourism industry, the efficiency of the tourism industry, and the capacity of the tourism reception in conjunction with the comprehensive level of tourism development, which are used to assess the overall driving effect of changes in tourism factors on regional transportation development. Finally, the factor loading coefficient, contribution rate and common factor difference are selected to analyze the influence factors (Table 5).

Table 5: Statistical results of interaction between transportation industry and tourism industry in Guangxi from 2010 to 2022

Tourism factors	Factor loadings	Contribution rate (%)	R2	Traffic factors	Factor loadings	Contribution rate (%)	R2
	Factor 1				Factor 1		
Tourism industry scale	0.957	80.791	0.916	Infrastructure construction	0.685	62.951	0.469
Tourism industry benefits	0.987	94.548	0.974	Traffic Service	0.717	93.982	0.514
Tourism reception capacity	0.86	99.884	0.74				

When analyzing the mutual influence between tourism industry and transportation industry, it can be clearly seen that the development of Guangxi's tourism industry plays a crucial role in the improvement and enhancement of the local transportation network. Not only the contribution of tourism reception capacity index is as high as 99.884%, but also the remaining two indexes are over 80%. In short, the booming development of Guangxi's tourism industry has an all-round positive impact on the transportation industry, which has an important driving effect.

And Guangxi's transportation industry also has a good supporting capacity for the development of tourism industry. However, it should be noted that the contribution rate of transportation services is as high as 93.982%, while the contribution rate of infrastructure construction changes to the development of tourism industry in Guangxi is relatively low only 62.951%. This is because tourism transportation in Guangxi is dominated by highways, which is not conducive to the improvement of the accessibility of Guangxi's tourism industry to the tourism industry outside the region and affects the development of the tourism industry. Therefore, Guangxi should accelerate the construction of highway network by strengthening the transportation environment in the region, and improve the

service support capacity of road network for tourism, so that the transportation can play a greater role in the development of tourism.

As a whole, through the factor-loaded kernel coefficient, it can be seen that the three tourism factors, namely, the scale of tourism industry, the efficiency of tourism industry, and the tourism reception capacity, are highly correlated with the development of the transportation industry, and the correlation between the infrastructure construction and the transportation service and the tourism industry is also high. In addition, the interaction between transportation industry and tourism industry in Guangxi is remarkable, and the development of transportation industry and tourism industry has promoted both sides. However, the contribution of tourism factor to the development of transportation is greater than that of transportation factor, which indicates that tourism development in Guangxi takes the initiative in the interaction between transportation industry and tourism industry.

IV. Conclusions and recommendations

Guangxi cities traffic and tourism integration industry development continues to be good, but traffic and tourism synergistic development is non-equilibrium evolution characteristics. 2010-2022 Guangxi traffic and tourism coordination degree of the overall improvement (average annual growth rate of 4.2%), but the transportation industry lagging type of region accounted for 78%, highlighting the structural mismatch between the infrastructure and the tourism industry demand. Typical performance: significant polarization effect: Beibu Gulf Economic Zone and Guilin formed a high degree of coordination cluster (degree of coordination > 0.75), while Wuzhou, Yulin and other cities in the transportation industry comprehensive level of growth rate of only 1/3 of the high coordination of the region; spatial spillover constraints: the marginal contribution of the transportation infrastructure to the tourism revenue with the decay of distance, the elasticity coefficient of the region 50 km away declined to 0.11 ($p < 0.05$), confirming the “proximity effect” of the tourism industry in Guangxi, the overall increase (4.2%), but the transportation industry lagging region accounted for 78%. This confirms the law of “neighborhood effect dominance”.

From 2010 to 2022, the relative difference between the coupling and coordination degree of transportation and tourism industry in Guangxi cities is gradually decreasing while the overall trend is increasing, which is in the optimization stage of transition from disorders to coordination, and there is still room for progress in Guangxi's transportation industry to achieve synchronous and coordinated development with the tourism industry. Industry type is mainly lagging type of transportation industry, most of the areas of transportation development is not effectively combined with tourism resources and tourism development needs, the transportation network of tourism services is not enough to protect the ability, still need to continue to improve the comprehensive transportation network.

From 2010 to 2022, the integration level of transportation industry and tourism industry in Guangxi cities shows a spatial imbalance. The level of coordination is “GuiNorth > GuiWest > GuiZhong > GuiDong > GuiNan”, and the inter-regional difference is “GuiNan > GuiWest > GuiZhong > GuiDong > GuiNorth”, but the balance of the level of coordination within each region has been improved compared with that of 2010. In addition, in 2022, there are already 12 cities in Guangxi that are on the verge of dislocation, and the level of integration is more uniform and patchy, which has initially formed regional synergy. Transportation industry and tourism industry resources are excellent, industrial advantages of the region or city such as the Beibu Gulf Economic Zone cities, international tourist city Guilin, etc. should continue to play a leading role in the formation of regional synergistic development pattern with the surrounding neighboring regions, shaping the advanced to promote the backward, the backward into the “backbone” of the good situation.

In different regions and at different times of development, the factors affecting the integrated development of the transportation and tourism industries are diverse. The influence of government policies on the transportation industry and tourism industry is undoubtedly, the scale of tourism industry, tourism industry efficiency, tourism reception capacity also has a significant positive effect on the development of the transportation industry, while the transportation industry, especially the infrastructure construction of tourism development but the contribution rate is relatively low. Therefore, it is still necessary to make efforts to promote the development of tourism transportation and the development of traffic-tourism integration by relying on policy support, regional synergistic development, and innovative development of enterprises.

Based on the above research, the following measures are proposed: (1) Improve the tourism transportation network. In the era of big traffic, Guangxi should speed up the construction of three-dimensional traffic network of “public, railway, water, navigation”, and integrate and rationally allocate various modes of transportation to realize comprehensive traffic integration and increase the capacity of the road network, which can not only reduce the waste of road network resources, but also shorten the round-trip distance between tourist attractions and even tourist cities, and shorten the travel time of tourists. Shorten tourists' travel time for tourism. (2) Enhance the transportation network's ability to guarantee tourism services. It is necessary to expand the function of passenger

transportation and tourism services in the transit places of tourists, enhance the function of cultural and tourism services in the hubs and nodes, such as airports, high-speed railway stations, bus stations and cruise terminals to enhance the function of tourism services or tourism promotion; accelerate and strengthen the construction of highway service zones of “tourism-type” and “recreation-type”; and build highway service areas in the areas leading to scenic spots and tourist attractions. service areas; add viewing platforms and self-driving camps along highways leading to scenic spots; and expand customized passenger transport services and relax customized standards by automobile transport companies. (3) Improve tourism transportation and promote regional cooperation. Guangxi has many scenic spots, many scenic spots are located in the outskirts of the city or townships, it is difficult to enter at the same time also brings new opportunities for development, through the improvement of this part of the tourism traffic, the inter-regional can break the administrative barriers, co-ordinated planning, and promote the construction of inter-regional tourism routes, especially Nanning and Guilin, as the core of the city of Guangxi, should play a leading role in giving full play to its own transportation, tourism resources, policies and other elements of the advantages of improving the transportation, tourism resources, and neighboring municipalities. Nanning and Guilin, as the core cities in Guangxi, should play a leading role, give full play to their advantages in transportation, tourism resources, policies and other factors, and improve the transportation and tourism resources linkage with neighboring cities, so as to drive the linkage development of tourism industry in various cities. While realizing the regional sharing of transportation and tourism resources, it is also conducive to the localities to play their own characteristics of resources, the formation of a hundred flowers blossomed benign competition, and improve the degree of coordination of regional industries and regional tourism attractiveness. (4) Strengthening intelligent tourism services. With the growing popularity of self-driving tours, we can fully rely on the “one-key tour of Guangxi” program to launch self-driving tourism service products. To “trip free and worry-free” as a selling point, the targeted introduction of tourism line customization services, to provide tourists with route recommendations, attractions or performances, tickets, restaurants and hotels booking, play tips recommended services, comprehensive self-driving tour and the advantages of the traditional tourism both sides, not only can allow tourists to save trouble, but also to meet the needs of tourists self-driving tour of the demand for freedom of travel, and better meet the people's multi-level, multi-level, multi-level, and multi-level travel services. Better meet the people's multi-level, personalized tourism travel needs.

Funding

This work was supported by research on promoting the deep Integration of culture and tourism in Guizhou (Major Project of Philosophy and Social Science Planning in Guizhou Province, No.: 23GZZB16).

References

[1] Marlina, E., & Natalia, D. A. (2017). Land transportation and tourism development. Journal of Economic & Management Perspectives, 11(2), 542-554.
[2] Pellegrino, F. (2021). Transport and tourism relationship. In Tourism in the Mediterranean Sea: An Italian Perspective (pp. 241-256). Emerald Publishing Limited.
[3] Tian, F., Yang, Y., & Jiang, L. (2022). Spatial spillover of transport improvement on tourism growth. Tourism Economics, 28(5), 1416-1432.
[4] Papatheodorou, A. (2021). A review of research into air transport and tourism: Launching the Annals of Tourism Research Curated Collection on Air Transport and Tourism. Annals of Tourism Research, 87, 103151.
[5] Bhattarai, K., Conway, D., Bhattarai, K., & Conway, D. (2021). Impacts of economic growth, transportation, and tourism on the contemporary environment. Contemporary Environmental Problems in Nepal: Geographic Perspectives, 563-662.
[6] Bergantino, A. S., Buonarota, M., Buongiorno, A., & Intini, M. (2023). Regional multimodal accessibility: Policies and strategies for sustainable tourism destinations in coastal areas. Research in Transportation Business & Management, 48, 100872.
[7] Smith, A., Robbins, D., & Dickinson, J. E. (2019). Defining sustainable transport in rural tourism: experiences from the New Forest. Journal of Sustainable Tourism, 27(2), 258-275.
[8] Zhang, J., & Zhang, Y. (2022). Tourism, transport infrastructure and income inequality: A panel data analysis of China. Current Issues in Tourism, 25(10), 1607-1626.
[9] Le-Klähn, D. T., & Hall, C. M. (2015). Tourist use of public transport at destinations–a review. Current Issues in Tourism, 18(8), 785-803.
[10] Yang, Y., Li, D., & Li, X. (2019). Public transport connectivity and intercity tourist flows. Journal of Travel Research, 58(1), 25-41.
[11] Zhou, H., Chi, X., Norman, R., Zhang, Y., & Song, C. (2024). Tourists' urban travel modes: Choices for enhanced transport and environmental sustainability. Transportation Research Part D: Transport and Environment, 129, 104144.
[12] Ouariti, O. Z., & Jebrane, E. M. (2020). The impact of transport infrastructure on tourism destination attractiveness: A case study of Marrakesh City, Morocco. African Journal of Hospitality, Tourism and Leisure, 9(2), 1-18.
[13] Benhaddou, K. S. (2021). Le transport: Un facteur de compétitivité des agences de tourisme et de voyage/Transportation: A Factor of Tourism and Travel Agencies competitiveness. Revue d'économie et de statistique appliquée, 18(2), 81-101.
[14] Ivankova, V., Gavurova, B., Bačík, R., & Rigelský, M. (2021). Relationships between road transport infrastructure and tourism spending: A development approach in European OECD countries. Entrepreneurship and Sustainability Issues, 9(2), 535.
[15] Kolupaev, A. A., Redkin, A. G., Voinova, N. E., Karabasheva, M. R., Rzayev, A. Y. O., & Makhanova, T. A. (2018). Main attributes of tourism
[16] transportation infrastructure formation. International Journal of Mechanical Engineering and Technology, 9(12), 1185-1197.