

Research on the Coupled and Coordinated Development of Tourism Informatization and Regional Tourism Economy in Jilin Province

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Abstract: This study is focused on developing an integrated coordination model designed to conduct an empirical assessment of the evaluation metrics and their respective weights concerning the tourism sector and regional economic growth in Jilin Province. By analyzing the level of coupling and coordination between these two domains, the findings indicate that, although the coordination level currently falls within the expected range, it remains suboptimal. This is primarily due to the relatively modest comprehensive evaluation scores of both the tourism informatization framework and the regional tourism economic system. To improve the level of coordination, this paper suggests several strategic measures. These include enhancing investments in information technology infrastructure and fostering the development of specialized talent. Such measures aim to effectively advance the synchronized development of the tourism sector and regional economic progress in Jilin Province.

Keywords: Coupling model, Tourism economy, Informatization.

1. Introduction

In the era of advanced information technology, the impact of informatization has significantly improved both the efficiency and quality of services within the tourism sector, while also fueling innovative growth opportunities. As information technology continues to evolve, the dynamic interplay between the tourism industry and regional economic development is set to encounter a range of new prospects and challenges. With the ongoing expansion of the domestic tourism market, eco-tourism in Jilin Province is poised to gain increased visibility and interest. To effectively address the evolving needs of tourists, enhance the promotion and marketing of tourism offerings, and boost the value of Jilin Province's tourism resources, it is essential to advance tourism informatization and improve the synergy between tourism informatization and regional economic development. This paper undertakes a comprehensive analysis of the current state of tourism informatization and regional tourism growth in Jilin Province. By developing a coupling evaluation model and indicator system for assessing the interplay between tourism informatization and regional tourism economy, the study provides an empirical investigation into their mutual development relationship. Additionally, the paper proposes practical recommendations to support the future coordinated advancement of

tourism informatization and regional economic development in Jilin Province. These recommendations aim to align with the evolving landscape of Jilin's tourism industry and contribute to the sustainable, long-term development of the integrated relationship between tourism informatization and regional economic growth.

The exploration of the connection between tourism informatization and regional tourism economies is advancing progressively. Although research internationally has reached a mature stage, domestic studies have lagged, with less developed outcomes. Wang Guanxiao [1] and colleagues investigated the coupling and coordination level between tourism and informatization across 31 provinces in China by creating an evaluation index system for assessing this relationship. Similarly, Jiang Yancheng [2] formulated a coupling development model to examine the integration of regional tourism economies with informatization, focusing on the coordination between tourism economy and informatization in the five provinces along the Northwest Silk Road. This research highlighted the current status and proposed solutions for rural tourism informatization. Yang Yan [3] and associates constructed an evaluation index system for rural tourism informatization and regional tourism economy, applying the Analytic Hierarchy Process (AHP) model to assign weights to evaluation indicators and develop a coupling evaluation model. Their study, which analyzed the informatization and economic development levels in four-star rural tourism areas across 13 prefecture-level cities in Jiangsu Province, assessed the coordination relationship between these factors. Huang Dongming [4] focused on Hunan Province, devising both an evaluation index system and a coupling coordination model for the tourism industry and regional economic development. Overall, existing literature, both domestic and international, primarily addresses the tourism industry's relationship with regional economic development, with most research employing qualitative methods and fewer utilizing quantitative approaches. To address this gap, the present paper constructs a comprehensive coupling coordination evaluation index system for tourism informatization and regional tourism economy. This study employs various quantitative methods, including comprehensive evaluation index functions, coupling degree calculations, and coordination indices, to analyze the coupling coordination relationship between tourism informatization and regional tourism economy in Jilin Province from 2018 to 2022. The research categorizes different levels and types of coordination and offers actionable recommendations for the future integrated development of tourism informatization and regional economic growth in Jilin Province. These recommendations aim to support and guide economic development strategies for Jilin and other similar provinces.

2. Examination of the Integrated Development and Coordination Between Tourism Informatization and Regional Tourism Economy in Jilin Province

2.1. Research Methodology

In this research, the focus is placed on two key subsystems: the tourism informatization system and the regional tourism economy system, both of which are investigated in terms of their coordinated interactions [5]. To analyze the relationship between these interconnected systems, a coupling coordination model is developed. Coupling, in this context, refers to the interaction where two or more systems influence one another through various forms of mutual impact. Coordination, on the other hand, denotes a favorable and harmonious interaction between these systems, characterized by a consistent and beneficial relationship that fosters synergy and positive feedback within and between the systems [6]. Building on an extensive analysis of existing literature and empirical research, this paper develops a detailed coupling coordination model specifically designed to assess the integrated growth of tourism informatization and the regional tourism economy in Jilin Province from 2018 to 2022.

2.2. Selection of Evaluation Indicators and Data Sources

In adherence to principles of scientific rigor, relevance, comparability, operability, and association, a set of indicators is meticulously selected to evaluate both the tourism industry and the regional economy [7]. These indicators are derived from a dual perspective, encompassing both tourism informatization and regional tourism economic development. The chosen indicators are detailed in Tables 1 and 2, which illustrate the specific metrics employed in this study. For the tourism informatization system, the evaluation framework includes three primary indicators and nine secondary indicators. These indicators are designed to capture various aspects of informatization, such as technological infrastructure, digital tools, and the effectiveness of information systems within the tourism sector. On the other hand, the regional tourism economy system is assessed using three primary indicators and eleven secondary indicators, focusing on economic performance metrics, tourism-related revenue, employment figures, and other relevant economic factors. To ensure the accuracy and credibility of the data utilized in this study, all information is sourced from reputable and authoritative publications. The primary data sources include the China Tourism Statistical Yearbook, the Jilin Statistical Yearbook, the Jilin Statistics Bureau, and the Jilin Province Communications Administration.

2.3. Development of a Model for Integrating Tourism Informatization and Regional Tourism Economy

2.3.1. Data Standardization

The measurement bases and standards of the indicators for the two subsystems in this paper are inconsistent, making direct comparison impossible. To eliminate the impact caused by differences in measurement standards, the indicators must be standardized for effective analysis. Summarizing previous research results, data standardization methods include extremum method, standardization method, and efficacy coefficient normalization method, among others [8]. This paper uses the extremum method for dimensionless processing, with the specific calculation formula as follows:

$$d_{ij} = \frac{(x_{ij} - x_{ij\min})}{(x_{ij\max} - x_{ij\min}) + 0.0001} \quad (1)$$

Where x_{ij} represents the value of the j -th indicator in the i -th year; $x_{ij\max}$ is the maximum value of the j -th indicator; $x_{ij\min}$ is the minimum value of the j -th indicator; and d_{ij} is the standardized value, which falls within the interval $[0, 1]$. Adding 0.0001 to the entire formula prevents the occurrence of zero or negative values.

2.3.2. Indicator Weights

Given its practical applicability and the objective nature of its outcomes, this paper employs the entropy method to calculate the weights assigned to each indicator [9]. The specific formulas used in this methodology are detailed as follows:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}} \quad (2)$$

$$e_{ij} = -k \sum_{i=1}^m p_{ij} \ln p_{ij} \quad k > 0, 0 \leq e_{ij} \leq 1 \quad (3)$$

$$g_j = 1 - e_{ij} \quad (4)$$

$$w_{ij} = \frac{g_j}{\sum_{j=1}^n g_j} \quad (5)$$

In the calculation process, let p_{ij} represents the proportion of the standardized value of the j -th indicator in the i -th year relative to the total for that specific indicator; $k = \frac{1}{\ln m}$, the variable m represents the number of years included in the study; e_{ij} the entropy value for the j -th indicator, denoted as e_{ij} , quantifies the level of uncertainty or dispersion in the data for that indicator; the difference coefficient, g_j is a measure of the variability among the values of the j -th indicator, and larger difference coefficients suggest a greater impact on the overall indicator; and the weight of the j -th indicator w_{ij} , reflects its relative importance based on its entropy and difference coefficients. Detailed calculations and results for these indicators and their weights are presented in Tables 1 and 2.

2.3.3. Establishing the Evaluation Function for the Tourism Informatization System

$$U_1 = \sum_{i=1}^n w_{ij} N_{ij} \quad (6)$$

Additionally, U_1 represent the comprehensive evaluation function value of the tourism informatization system, where t is the total number of indicators considered ($t = 1, 2, \dots, t$). Each indicator's weight in this system is denoted as w_j .

2.3.4. Establishing the Evaluation Function for the Regional Tourism Economy System

$$U_2 = \sum_{z=1}^n w_j M_{ij} \quad (7)$$

Similarly, U_2 is the comprehensive evaluation function value for the regional tourism economy system, with z representing the total number of development indicators ($z = 1, 2, \dots, z$). The weight of each indicator in this system is represented by w_j .

2.3.5. Calculation of Coupling Degree and Coordination Degree

$$C = 2 \times \left[\frac{U_1 \cdot U_2}{(U_1 + U_2)^2} \right]^{\frac{1}{2}} \quad (8)$$

$$T = \alpha U_1 + \beta U_2 \quad (9)$$

$$D = \sqrt{C \cdot T} \quad (10)$$

The coupling degree between the two systems is represented by C . The comprehensive coordination index, T , evaluates how the overall development levels of the two systems influence their coordination. Since the coupling degree only reflects interaction strength and does not fully capture the coordinated development between the tourism informatization and regional tourism economy systems, a coupling coordination degree model is employed. This model, denoted by D , ranges from 0 to 1, where lower values indicate less coordination and higher values reflect greater coordination.

α 、 β $\alpha \cdot \beta$ are undetermined weights that reflect the influence coefficient between system 1 and system 2. In this paper, since both systems are considered equally important to the study, it is set that $\alpha = \beta = 0.5$.

Table 1: Evaluation Indicator System and Weights for Tourism Informatization

Category	Primary Indicator	Weight	Secondary Indicator	Weight
Tourism Informatization System U_1	Informatization Infrastructure U_{11}	0.4852	Mobile Phone Penetration Rate	0.1402
			Internet Penetration Rate	0.0897
			Length of Optical Cable Lines	0.2553
	Information Industry Operation U_{12}	0.3141	Total Telecommunications Business	0.1231
			Fixed-Line Telephone Users	0.0995
			Number of Cable TV Users	0.0915
	Informatization Development Environment U_{13}	0.2007	GDP Per Capita	0.0761
			Local Fiscal Revenue	0.0529
			Proportion of Population with Higher Education (Associate Degree or Above)	0.0717

Table 2: Evaluation Indicator System and Weights for Regional Tourism Economy

Category	Primary Indicator	Weight	Secondary Indicator	Weight
Regional Tourism Economy System U_2	Market Demand Scale U_{21}	0.3651	Number of Domestic Tourists	0.0646
			Number of Inbound Tourists	0.1352
			Total Tourism Revenue	0.0671
			Tourism Foreign Exchange Earnings	0.1370
	Industrial Development Foundation U_{22}	0.3842	Number of A-level and Above Scenic Spots	0.0864
			Number of Star-Rated Hotels	0.1218
	Economic Benefits U_{23}	0.2507	Number of Travel Agencies	0.1105
			Proportion of Total Tourism Revenue in Tertiary Industry	0.0685
			Proportion of Total Tourism Revenue in GDP	0.0704
			Per Capita Tourism Expenditure	0.0659
			GDP Per Capita	0.0725

2.4. Results Analysis

2.4.1. Classification of Coupling Coordination Levels

The coupling coordination level provides an assessment of how well two systems are developing in tandem by comparing their respective performance metrics. This level is divided into ten distinct intervals, ranging from 0 to 1, with each interval corresponding to a specific degree of coordination between the systems. Lower values within this range indicate a significant imbalance or misalignment in the coordination of the systems, suggesting that they are not effectively supporting each other's development. In contrast, higher values reflect a higher degree of integrated development, where the

systems are well-coordinated and mutually beneficial [10]. The detailed classification of these coupling coordination levels is provided in Table 3.

Table 3: Standards for Classifying Coupling Coordination Levels

Coupling Coordination Degree	Level	Coupling Coordination Degree	Level
0.00 – 0.09	Extreme Imbalance	0.50 – 0.59	Barely Coordinated
0.10 – 0.19	Severe Imbalance	0.60 – 0.69	Primary Coordination
0.20 – 0.29	Moderate Imbalance	0.70 – 0.79	Intermediate Coordination
0.30 – 0.39	Mild Imbalance	0.80 – 0.89	Good Coordination
0.40 – 0.49	On the Brink of Imbalance	0.90 – 1.00	Optimal Coordination

2.4.2. Analysis of Tourism Informatization and Regional Economic Development Levels

An examination of the comprehensive scores for both tourism informatization and regional economic development in Jilin Province reveals significant trends. The score for tourism informatization initially decreased from 0.4974 in 2018 to 0.2891 in 2019, indicating a period of reduced performance. However, from 2019 to 2022, the score showed a steady increase, reaching 0.4909 by 2022, signifying ongoing improvements in tourism informatization efforts. In contrast, the comprehensive score for regional economic development experienced a consistent decline from 2018 to 2022, with the most significant drop occurring between 2019 and 2020, where the score fell dramatically from 0.7211 to 0.3192. This decline was influenced by four low-weight indicators: tourism revenue as a percentage of the tertiary sector (0.0685), tourism revenue relative to GDP (0.0704), per capita tourism expenditure (0.0659), and per capita regional GDP (0.0725). The COVID-19 pandemic exacerbated this downturn by halting the growth of regional tourism in Jilin Province, leading to a significant decrease in the overall economic development score during this challenging period.

Regarding the coupling degree, there was no substantial difference between the years, with scores hovering around 0.9. The highest score was in 2020, with a coupling degree of 0.9904, while the lowest was in 2022, with a coupling degree of 0.8608. The small differences observed in the coupling degrees between the two systems were insufficient for accurately assessing the degree of coordinated development.

In terms of coupling coordination degree, the systems generally maintained a state of coordination, although with only minor fluctuations [11]. In 2018, both systems were at an intermediate level of coordination, achieving their highest coupling coordination degree for the period spanning from 2018 to 2022. This peak reflected a high level of synergy between tourism informatization and regional tourism economic development, though there was still potential for further enhancement in tourism informatization services and management. From 2019 to 2021, the systems were in the primary coordination stage, exhibiting minimal variation in their coupling coordination degree. This period was characterized by a lack of substantial progress, with tourism informatization development in 2019 being notably insufficient and the growth of the regional tourism economy in 2020 and 2021 being less promising. This stagnation highlighted a need for improved performance and integration efforts. By 2022, the level of coordination had significantly declined, reaching its lowest point with the least favorable coupling coordination degree of the entire period. This decline indicated that regional tourism economic development had deteriorated, resulting in a considerable gap between the two systems. The situation underscores an urgent need for focused efforts to enhance and revitalize

regional economic tourism development to bridge this gap and improve overall coordination in the future.

As for the coupling types, in 2018-2019, $U_1 < U_2$, regional economic development outpaced the development of tourism informatization, with the coordination type being characterized as a lag in tourism informatization. During the specified period, the influence of regional economic development on the tourism sector in Jilin Province was notably more significant compared to the impact of tourism informatization. This stage saw significant fluctuations in the gap between the two systems, as people had not yet recognized the role of informatization in promoting tourism economic development, leading to a lag in the development of tourism informatization. However, this fluctuation spurred rapid progress in various indicators of the tourism informatization system, laying the foundation for its accelerated development in subsequent years. From 2020 to 2022, $U_1 > U_2$, tourism informatization development surpassed regional economic development, with the coordination type characterized as a lag in regional tourism economy. Conversely, the effect of tourism informatization on the tourism industry's growth in Jilin Province surpassed that of regional economic development. This discrepancy can be attributed to the swift progress in the digital age, which facilitated the extensive adoption of tourism informatization and accelerated its development compared to the more gradual pace of regional economic growth.

Table 4: Levels of Tourism Informatization and Regional Economic Development in Jilin Province and the Division of Coupling Coordination Degree Types

Year	U_1	U_2	C	T	D	Coordination Level	Coordination Type
2018	0.4974	0.7645	0.9774	0.6310	0.7853	Intermediate Coordination	Tourism Informatization Lagging
2019	0.2891	0.7211	0.9040	0.5051	0.6757	Primary Coordination	Tourism Informatization Lagging
2020	0.4216	0.3192	0.9904	0.3704	0.6057	Primary Coordination	Regional Tourism Economy Lagging
2021	0.4639	0.3063	0.9789	0.3851	0.6140	Primary Coordination	Regional Tourism Economy Lagging
2022	0.4909	0.1597	0.8608	0.3253	0.5292	Barely Coordinated	Regional Tourism Economy Lagging

Jilin Province's overall scores for tourism informatization each year show minimal variation, but there are significant discrepancies in the scores for regional tourism economy. Market demand scale and industry development foundation are the primary influencing factors. Beginning in 2020, the COVID-19 pandemic has led to a gradual decline in market demand, resulting in notable decreases in key metrics such as the number of tourists. The interaction between the two systems is characterized by mutual reinforcement and interdependence. Advances in information technology foster growth within the regional tourism economy, while improvements in the regional tourism economy spur ongoing innovation and upgrades in information technology. As a result, when both systems reach a higher level of development, the degree of coupling coordination between them also increases. Conversely, it is lower when both are at lower levels. Since 2019, Jilin Province's informatization comprehensive score has steadily increased. Key influencing factors include the popularity of mobile phones and the length of optical cable lines. The substantial increase in internet penetration and optical cable line length has led to a significant rise in Jilin Province's informatization comprehensive score. Although the regional tourism economy has declined considerably, the two systems have not reached a state of imbalance.

3. Conclusion and Discussion

This study examines the current state of the tourism industry in Jilin Province and uses both tourism and regional economic indicators to develop a comprehensive evaluation index system for assessing the tourism information system alongside the regional tourism economic system. The evaluation

focuses on the level of coupling coordination and the degree of alignment between tourism information systems and regional economic development in Jilin Province over a five-year period. [12]. Overall, there is a noticeable gradual decline in the coordinated development between the two systems. Key factors influencing the progress of tourism information and the regional tourism economy in Jilin Province include mobile phone penetration rates, the extent of optical cable infrastructure, the total volume of telecommunications services, the number of inbound tourists, foreign exchange earnings from tourism, the quantity of star-rated hotels, and the number of travel agencies.

The degree of coupling coordination between tourism informatization and the regional tourism economy has been experiencing a gradual decline. The coordination status of the two systems fluctuates based on their development levels at different points in time. When both tourism informatization and the regional tourism economy reach advanced levels, their coordination level also improves. Ongoing enhancements in infrastructure, higher economic standards, and robust government support contribute significantly to the flourishing development of the tourism sector. At the same time, the mutual promotion between tourism informatization and regional tourism development aims for improved coordination quality. However, if tourism informatization is at a low level and there is inadequate investment in infrastructure, management, and services related to informatization, achieving rapid progress in tourism informatization becomes challenging. Although the systems are still in good coordination, the quality of this coordination is low. When both tourism informatization and regional economic development are at low levels, although they have not entered a state of imbalance, they are in a barely coordinated state. The mutually reinforcing and beneficial interaction between them is weak, posing a constant risk of imbalance.

The quantitative research method used in this study is somewhat representative, but the study only covers five years in Jilin Province and does not include multiple years or dimensions, which limits its comprehensiveness [13]. Looking into the future, Jilin Province's tourism sector is experiencing significant growth, marked by rapid advancements in recent years. The integration of information technology has significantly enhanced the efficiency of managing regional tourism operations. The reciprocal enhancement and interaction between the tourism informatization system and the regional tourism economy have contributed to a significant increase in tourism metrics in Jilin Province, positioning its tourism sector as a prominent feature within China.

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