



The Coordinated Development of Transportation Industry and Tourism Based on Coupling Model

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Abstract. To build a unified national market, the development of transport industry is the basis of inter-regional exchanges, as China enters a new era, the main contradiction has become the contradiction between the people's growing needs for a better life and the unbalanced and insufficient development, the tourism industry relies on the special functions of the transport industry as the basis for the rapid development of the industry as a new industry, the transport industry and the tourism industry promote each other and influence each other. This paper invokes the coupling model, analyses the interaction mechanism of the two systems, establishes the index system and evaluation model of the two systems, and takes Yunnan Province as an example for empirical analysis. From 2011 to 2021, the transport industry and tourism industry in Yunnan Province have achieved coordinated development, and the overall coupling evaluation level shows an upward trend. In 2016 and before, the development of the tourism industry mainly relied on the function of the transport industry and surpassed the transport industry at a faster rate. However, since 2017, tourism has started to drive the development of the transport industry. Compared to tourism, the development of transport industry is more stable. In the future, Yunnan Province should focus on the development of the transport industry, as it limits the development rate of tourism to a certain extent. Compared with tourism, the current level of the transport industry is relatively weak, and there is still much room for improvement.

Keywords: Coupled Modelling, Entropy Approach, Industrial Synergy

1 Introduction

The Opinions of the CPC Central Committee and State Council on Accelerating the Construction of a Nationally Unified Large Market, released on April 10, 2022, outlines requirements for building such a market. China, the world's third-largest country with complex terrain, faces challenges in constructing a nationwide market, testing its transport capacity. The transport industry is crucial for regional exchanges.

Tourism reflects the integration of national strategies and needs. The 20th Party Congress report emphasizes building a strong socialist modernization country, with tourism

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playing a key role in economic and social modernization. As the economy shifts to high-quality development and people's needs for a better life grow, tourism's dual role as an economic and happiness industry becomes more significant. It enhances people's well-being beyond economic growth. Recent reports confirm tourism's importance in people's lives, with diversification and personalization trends obvious. These changes reflect national aspirations and promote the industry's transformation to high-quality development.

A region's transport industry is vital for tourism. Poor development hinders tourists' visits, blocking tourism economy growth. Conversely, advanced transport facilitates tourists' travel, driving tourism development and bringing wide economic benefits, including accommodation, catering, transport, and entertainment. May 19, 2011, was designated 'China Tourism Day'. We studied Yunnan's transport and tourism systems from 2011 to 2021 using a coupled evaluation model, analyzing their coordinated development.

The application of coupled modeling spans a diverse array of research domains. Wang J (2024) undertakes a profound exploration of the pivotal relationship between the tourism industry and urban ecological resilience within regions distinguished by their ethnic arts heritage, thereby contributing significant insights into the dynamics of coupled natural-human systems concerning water allocation and utilization in water-scarce environments [1]. Cameron et al. (2022) endeavor to elucidate these dynamics, offering crucial perspectives on how natural and anthropogenic factors interplay in such contexts [2].

Wang Yi et al. (2015) discusses the coordinated relationship between the modern service industry and urbanization, and conducts an empirical study with Changshu City in Jiangsu Province as a case study[3]. From an agricultural standpoint, Ren Zhiyuan et al. (2011) have ventured into examining the harmonious coexistence and development between the agricultural ecological environment and the agricultural economy, emphasizing the need for balanced growth [4]. Additionally, the coupling coordination degree model has been employed by researchers to assess the existing level of synchronization between the tourism and logistics sectors in Anhui Province, shedding light on potential areas for enhancement, Donghe L et al. (2018) said [5].

Furthermore, Zhang W and Wen L (2023) aimed at analyzing the coordination effects and the underlying factors influencing the interplay between the tourism economy and transportation infrastructure in Shaanxi Province endeavors to foster sustainable development within the region's tourism economy [6]. This analysis underscores the importance of understanding and optimizing the interactions between these two critical components of regional economic health.

Li and Gao (2023) effectively utilized the coupling coordination model to explore the complex interactions between tourism space, local economy, and population dynamics. Their study highlights the importance of this model in understanding the intricate relationships within the tourism sector [7]. This methodological approach facilitates a nuanced understanding of how these various systems intermesh, ultimately informing strategies for sustainable tourism and regional development.

In summary, the coupled modeling framework emerges as a versatile tool in examining the multifaceted relationships within and between natural and human systems,

offering profound implications for policy formulation and sustainable development initiatives across diverse domains.

2 Research Methodology

2.1 Meaning of Coupling

Coupling is a concept in the field of physics, refers to the phenomenon of two or more than two or more systems interacting and influencing each other, coupling is divided into benign coupling and bad coupling, benign coupling refers to the development of coordination between the systems or between each element in different systems to promote each other, and the opposite is true for bad coupling.

Incorporating the coupling model used by Wang Yi, Ding Zhengshan, Yu Maojun, et al. (2015) and Ren Zhiyuan, Xu Qian, Yang Ren (2011), the following establishes the model for this paper.

2.2 Coupling Evaluation Model

Assuming μ_{ij} that is the j -th indicator in the i -th system ($i=1,2,3,\dots, n$; $j=1,2,3,\dots, m$), each μ_{ij} has a sequence called x_{ij} , and the length of the x_{ij} sequence is the number of samples collected for that indicator μ_{ij} . The first step of comprehensive evaluation: according to the direction of the indicator is divided into positive and negative indicators, positive indicators is that the larger the value of the indicator, the higher its comprehensive evaluation, representing the indicators of economic development growth; negative indicators is that the larger the value of the indicator, the lower its evaluation, representing the indicators of economic development shrinkage. In order to eliminate the influence of different units between different indicators and different orders of magnitude of indicator values on the comprehensive evaluation, the positive and negative indicators will be dimensionless. The formula is as follows:

$$\mu_{ij} = \begin{cases} \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} & \mu_{ij} \text{ is a positive indicator} \\ \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} & \mu_{ij} \text{ is a negative indicator} \end{cases} \quad (1)$$

Each μ_{ij} was homogenized to calculate the share of each p_{ij} in the whole in different years.

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

For the j -th indicator, its information entropy value e_j represents the discrete degree of the indicator, and the smaller its entropy value, the more discrete the value of the

indicator is, indicating that the indicator has a greater impact on the comprehensive evaluation, and the calculation of entropy value is related to the size k of the data sample size. The formula is as follows:

$$e_j = -\frac{\sum_{i=1}^n p_{ij} \ln p_{ij}}{\ln(k)} \quad (3)$$

The coefficient of variation g_j of the j -th indicator is equal to the difference between the information entropy value of the indicator e_j and 1, which affects the size of the weight. The larger the coefficient of variation, the greater the importance to the evaluation and the greater the weight. The formula is as follows:

$$g_j = 1 - e_j \quad (4)$$

Calculate the weight of the j -th indicator w_j , calculated using the coefficient of variation, the higher its coefficient of variation, the more important it is for the evaluation, i.e., the larger the weight. The sum of the weights of the indicators in each system should be 1. The formula is as follows:

$$w_j = \frac{g_j}{\sum_{j=1}^m g_j} \quad \sum_{j=1}^m w_j = 1 \quad (5)$$

Comprehensive evaluation model of the results of the comprehensive evaluation value U_i based on the j -th indicator weights and the j -th indicator share can be calculated. The formula is as follows:

$$U_i = \sum_{j=1}^m w_j p_{ij} \quad (6)$$

Using the capacity coupling model from physics, the coupling degree C and comprehensive evaluation index T can be calculated, where a and b are coefficients determined by system development levels and variances. High coupling may indicate various situations, so the coupling coordination degree D is used as the final reference. D considers both coupling degree and comprehensive evaluation index, avoiding situations where high coupling does not reflect ideal development. Coupling degree refers to indicator mutual influence, while coupling coordination degree reflects harmony and consistency, indicating the level of coordination.

$$C = \sqrt{\frac{U_1 U_2}{(U_1 + U_2)^2}} \quad T = aU_1 + bU_2, \quad a + b = 1 \quad D = \sqrt{CT} \quad (7)$$

3 Empirical Analysis

3.1 Data Sources

The data in this paper mainly comes from Yunnan Statistical Yearbook and China Tourism Statistical Yearbook from 2011 to 2021, as well as CSMAR Cathay Pacific database, and some of the missing data are supplemented by indirect calculation and weighted average method.

3.2 Overview of Yunnan Province

Since 2012, Yunnan Province has prioritized transportation development, continuously accelerating the construction of a comprehensive transportation system. Key projects like the "Double Ten" infrastructure plan, county-level expressway accessibility and inter connectivity, railway network expansion, civil aviation infrastructure strengthening, water transportation upgrade, and postal network coverage have been implemented. A "seven highways outbound to neighboring provinces and five highways crossing borders" expressway network has been formed, with continuous extensions to the railway and aviation networks.

In January 2015, President Xi pointed out that lagging transportation infrastructure was a significant constraint on Yunnan's development. Since the implementation of the 13th Five-Year Plan, Yunnan's total investment in transportation has reached RMB 1.54 trillion, with road and waterway investments ranking first nationwide for four consecutive years. Yunnan's complex terrain necessitates a strong transportation system to support economic development, social progress, and improvement of people's livelihood.

Yunnan is renowned for its unique plateau scenery, frontier attractions, and ethnic customs, with over 1,000 scenic spots, including 9 5A-grade scenic spots. With 25 ethnic minorities, Yunnan attracts a large number of domestic tourists, driving the development of the tourism industry. This paper selects Yunnan as a case study to analyze the coupling and coordination relationship between the transportation system and the tourism system.

3.3 Evaluation Indicator System Construction

Based on influencing factors and characteristic indicators, the transportation system has three primary indicators (transportation employment, mileage, volume) with 15 secondary indicators, while the tourism system has three primary indicators (tourist numbers, revenue, employment) with 10 secondary indicators. All 25 indicators are positive. See Table 1 below.

Table 1. Coupled System System and Indicators

System	Indicators 1	Weights	Indicators 2	Weights	Direction
Transportation	Employment	0.24	Railroad	0.25	positive
			Highway	0.15	positive
			Waterborne	0.40	positive
			Air	0.20	positive
	Distance	0.29	Railroad	0.36	positive
			Inland waterway	0.28	positive
			Highway	0.36	positive
	Quantity	0.47	Passengers	0.10	positive
			Passengers by railway	0.20	positive
			Passengers by highway	0.10	positive

			Passengers by water	0.10	positive
			Goods	0.10	positive
			Goods by railway	0.14	positive
			Goods by highway	0.10	positive
			Goods by water	0.16	positive
Tourism	Quantity	0.25	Domestic tourists	0.47	positive
			Overnight tourists	0.27	positive
			Inbound tourists	0.26	positive
	Income	0.37	Total tourism revenue	0.36	positive
			Domestic tourism revenue	0.37	positive
			International tourism revenue	0.27	positive
	Employment	0.38	Secondary industry	0.32	positive
			Tertiary Industry	0.17	positive
			Secondary Industry (%)	0.33	positive
			Tertiary Industry (%)	0.18	positive

3.4 Empirical Findings

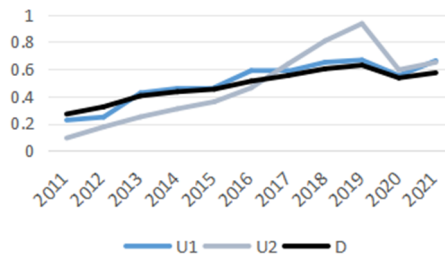


Figure 1. Line graph of year-to-year changes in coupling indicators

Based on the aforementioned research methodology, the comprehensive evaluation values U1 and U2 for the transportation system and tourism system in Yunnan Province, respectively, as well as the coupling degree C and coupling coordination degree D between the two systems, were calculated. In this context, the undetermined coefficients a and b were both set to 0.5. The coupling evaluation was provided with reference to the coupling coordination degree, and the coupling results are presented in Table 2 and Figure 1. As shown in the table, both the transportation and tourism industries have gradually grown over time but declined in 2019-2020. Tourism saw a significant drop of 36.3% (from 0.9331 to 0.5940) due to COVID-19. Citizens stayed home to reduce mobility and gatherings, aiding pandemic control. This setback followed previous setbacks in 2002 (SARS) and 2008 (global financial crisis). COVID-19's longer duration continues to impact tourism, highlighting its vulnerability. Despite this, tourism has grown rapidly since the 21st century, with a 2021 comprehensive evaluation value of 696.4% of 2011's. Tourism's peak in 2019 was 1001.2% of 2011's value, indicating high potential. In contrast, the transportation industry was less affected by COVID-19

due to its inclusion of cargo transport. It has a stronger foundation than tourism, with higher comprehensive evaluation values from 2011 to 2016. After 2020, the transportation industry quickly recovered, showing its fundamental importance to Yunnan Province.

Table 2. Comprehensive evaluation value, coupling degree, coupling coordination degree and coupling evaluation

Year	U1	U2	D	Coupling Evaluation
2011	0.22	0.09	0.27	Moderate Dysfunctional Decline
2012	0.25	0.17	0.32	Mild Dysfunctional Decline
2013	0.42	0.25	0.40	
2014	0.46	0.31	0.43	On the verge of dysfunctional decline
2015	0.46	0.36	0.45	
2016	0.59	0.46	0.51	
2017	0.58	0.64	0.55	Barely coordinated development
2018	0.65	0.8	0.60	
2019	0.67	0.93	0.63	Elementary coordinated development
2020	0.55	0.59	0.53	
2021	0.66	0.65	0.57	Barely coordinated development

From 2011 to 2021, Yunnan's transportation and tourism industries showed a trend of coupled and coordinated development, rising slowly. Early years saw moderate imbalance and decline, shifting to light coordination in 2012, then near imbalance from 2013 to 2015. In 2016, the trend turned to coordinated development, becoming reluctantly coordinated in 2016-2017, primarily coordinated in 2018-2019, and reluctantly coordinated again in 2020-2021 due to COVID-19. The only significant imbalance was in 2019-2020. However, in 2021, both systems resumed upward trends, indicating strong potential for coupled and coordinated development. With government support, they will continue to enhance their levels, striving for higher coupling evaluations.

By comparing U1 (transportation) and U2 (tourism) comprehensive evaluation values: $U1 > U2$ indicates lagged tourism development; $U1 = U2$ indicates balanced development; $U1 < U2$ indicates lagged transportation development. From 2011 to 2016 and in 2021, tourism lagged behind transportation. From 2017 to 2020, transportation lagged behind tourism, as tourism surpassed it at a faster pace. While transportation is tourism's foundation, it also restricted tourism's development during this time by not keeping pace.

4 Conclusions and Recommendations

Based on the analysis of the coordinated development mechanism of mutual dependence and mutual promotion between the transportation and tourism systems in Yunnan Province, this paper collects relevant indicator data for these two systems from 2011 to 2021. An indicator system for transportation and tourism is established, and the coupling model in physics is employed to evaluate the coupling between the two systems. Through empirical research and analysis, the following conclusions are drawn: (1)

There is a coupling and coordinated development relationship between transportation and tourism systems, where indicators influence each other, promoting their joint development. (2) From 2011, Yunnan's transportation and tourism levels have shown annual improvements and an upward trend, indicating strong development potential. (3) Before 2016, tourism relied on transportation as its foundation but surpassed it as an emerging industry. From 2017 onwards, tourism promoted transportation's development, creating a mutual promotion effect. (4) Transportation is the foundation for tourism and many industries, showing good stability and resilience to external factors. In contrast, tourism's development is fragile and easily affected by factors like natural disasters and economic crises.

Based on the above four conclusions regarding the coupling and coordinated development relationship between transportation and tourism in Yunnan Province, this paper provides the following specific policy recommendations: (1) Strengthen transportation infrastructure to enhance tourism transportation convenience, particularly to major attractions (roads, railways, air transport). Improved accessibility and convenience will attract more tourists and enhance their satisfaction and experience quality. (2) Promote deep integration between tourism and transportation for coordinated development. Yunnan Province should fully utilize the mutually promotional relationship between tourism and transportation to drive their deep integration. For example, incorporate tourism elements into transportation services through sightseeing buses and tourist trains to enhance tourists' travel experiences. Simultaneously, strengthen information sharing and collaborative cooperation between tourism and transportation departments to jointly formulate tourism transportation development plans and policy measures, achieving optimal resource allocation and benefit sharing. (3) Enhance the risk resistance capability of tourism. Given the fragile nature of tourism development and its susceptibility to external factors, Yunnan Province should strengthen supervision and support for the tourism industry. For instance, establish a tourism risk warning and emergency response mechanism to promptly address the impacts of natural disasters, economic crises, and other emergencies on tourism. (4) Promote high-quality tourism development in Yunnan by improving product quality, cultural connotations, and creating distinctive brands and routes. Enhancing tourism's competitiveness will further promote transportation development, fostering a beneficial interaction and coordinated growth between the two.

In summary, in the process of developing tourism in Yunnan Province, it is essential to fully leverage the foundational supporting role of the transportation industry while focusing on improving the quality and risk resistance capability of tourism to achieve deep integration and coordinated development between the two.

References

1. Wang J. Research on the synergistic evolution of tourism economy and urban ecological resilience based on coupling model in the context of ethnic arts[J]. *Applied Mathematics and Nonlinear Sciences*, 2024, 9(1):
2. Cameron W, Eric S, C. J C, et al. Water Allocation, Return Flows, and Economic Value in Water-Scarce Environments: Results from a Coupled Natural-Human System Model[J]. *Water*, 2022, 14(20): 3280-3280.

3. Wang Yi, Ding Zhengshan, Yu Maojun, et al. Quantitative analysis of the coordinated relationship between modern service industry and urbanization based on a coupling model: A case study of Changshu City, Jiangsu Province [J]. *Geographical Research*, 2015, 34(01): 97-108.
4. Ren Zhiyuan, Xu Qian, Yang Ren. Research on the coordinated development of agricultural eco-environment and economy in Shaanxi Province based on a coupling model [J]. *Journal of Arid Land Resources and Environment*, 2011, 25(12): 14-19.
5. Donghe L, Mengxia H, Hui Z. Coupling and Coordinated Development of Tourism Supply and Tourism Demand under the Background of Supply-side Reform—Taking Anhui Province as an Example[J]. *Journal of Beijing University of Chemical Technology(Social Sciences Edition)*, 2018.
6. Zhang W, Wen L. Analysis of the Coordination Effects and Influencing Factors of Transportation and Tourism Development in Shaanxi Region[J]. *Sustainability*, 2023, 15(12):
7. Li L, Gao Q. Researching Tourism Space in China's Great Bay Area: Spatial Pattern, Driving Forces and Its Coupling with Economy and Population[J]. *Land*, 2023, 12(10):

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