

Coupling Coordination Between Rural Digitalization and Rural Tourism: Evidence from 253 Counties in China

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ABSTRACT

Rural digitalization and rural tourism are important tasks to achieve the goal of rural revitalization strategy, and researching whether there is a connection between them and the degree of association is helpful to accelerate the transformation of rural digitalization and promote the quality and upgrading of rural tourism. This paper constructs an evaluation system of rural digitalization and rural tourism, adopting 253 counties in China as samples to measure the development differences between regions of the two systems. A coupled coordination model is applied to explore the relationship between the two systems and reveals the distribution characteristics of the level of coupling and coordination in China. The findings show that the difference in the overall score of rural digitalization between counties is greater than that of rural tourism industry. There is a high degree of coupling between rural digitalization and rural tourism systems, and the two systems are currently at a barely coordinated stage in China. In addition, the degree of coordination varies significantly between counties, presenting a phenomenon of higher coupling coordination in the eastern coastal region, intermediate in the central and western inland regions, and lower in the northwest. This paper supports and validates some results of rural development projects in the research area to provide theoretical and decision support for coordinating rural digitalization and rural tourism services.

Keywords: Rural Digitalization, Rural Tourism, Coupled Coordination Models, China Rural

1. Introduction

Digital technology is a technology that relies on data to transform into a computer-recognizable language and processed, stored, analyzed, transmitted, and fed back, and it includes big data, cloud computing, artificial intelligence, the Internet of Things, blockchain, and 5G technology [1]. The development of digital technologies is driving the accelerated convergence of physical and digital spaces, which emerges in regional and inter-industry interactions and promotes the transformation of the

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economy and society through digitalization [2]. The application of digitalization is crucial for achieving rural revitalization, driving the development of new rural industries and new business models [3], promoting the innovative supply of services, and improving the effectiveness of management [4]. As an important component in rural revitalization strategies [5], rural tourism is a comprehensive carrier combining traditional agriculture and tourism and integrating agricultural production, cultivation resources, folk customs, and cultural characteristics in various ways [6].

The current literature examines the impact of digital technologies on agriculture and rural areas from different perspectives. There is no doubt that digitalization is also providing the motivation and innovation for the development of rural tourism, as information and communications technology (ICT) has changed the way in which tourists travel and their travel demands [7]. As a representative industry for rural revitalization, rural tourism is an essential element in improving the rural industrial structure, contributing to poverty eradication and unleashing rural vitality [8]. Previous research has established that digitalization promotes the upgrading of rural tourism. Through the integration of online and offline services, facilities, operational services [9], and the marketing promotion and management of scenic spots are empowered to achieve innovation in rural tourism services and management models [10]. Moreover, the adoption of digital technology can increase the probability of residents' participation in tourism and increase the average consumption level of tourists, which is conducive to promoting rural tourism consumption and improving social welfare [11]. Additionally, as a result of improving rural regulation and governance through digital technology, a sustainable and structured rural tourism ecosystem can be established and maintained [12]. The mobilization of rural tourism services online gives tourists a more convenient experience and meets their requirements more easily [13]. However, previous studies have mainly used a qualitative approach to explore the role and contribution of digitalization to rural tourism, and the literature has rarely evaluated the comprehensive level of development of rural digitalization and tourism, and the state of coupling and coordination utilizing a quantitative method, especially in developing countries.

A synergistic development of rural digitalization and rural tourism is the main purpose of this paper, which is an attempt to explore the development of rural tourism industry in the backdrop of digitalization, concentrating on the degree of coupling coordination between them. Applying the coupling and coordination model in physics, this paper constructs an index system for the development level of rural digitalization and rural tourism. We carry out a quantitative analysis of the degree of coupling and coupling coordination between rural tourism and rural digitalization by utilizing 253 counties from China, the purpose of which was to clarify the degree of coupling and correlation between them and diagnose the factors that may create an impact.

The findings should make an important contribution to the field of rural digitalization and tourism. Firstly, this study is the first to explore the interrelationship between rural digitalization and rural tourism by means of establishing rational evaluation indicators and models. Moreover, the coupled coordination model is introduced as a research method to deepen the understanding of the coordination relationship and interactions between the two. Secondly, the research sample data chosen for this paper is from the developing country of China to roll out an empirical study focusing on the assessment of rural development in emerging countries, in order to extend the existing literature. Finally, this investigation will not only provide a reference for the coupling relationship between rural digitalization and rural tourism in a move towards quality and coordinated development, but also serve as a scientific basis for digital construction to contribute to the development of rural tourism and the revitalization of the rural areas.

The overall structure of the study takes the form of six chapters, including this introductory part. In the next section, the article reviews and presents in detail the theory and literature. The following 3 chapters describe methodology, involving sources of sample data and coupled coordination models. The fourth section presents the results of the study. Then, some discussions of coupling relationships in 5 sections, and finally the paper ends with the conclusions and limitations of our research.

2. Literature Review

2.1. Definition of ICTs and Digitalization

ICTs are interpreted as digital technology tools that facilitate communication and information. They are systems and resources for the production, storage and dissemination of digital information in a computer-based technology that can support economic growth and development [14]. Digitalization is the process of transforming virtual information into digital information [15], which is in accordance with ICTs, and has a farther-reaching impact than ICTs [16]. Chatterjee et al. [17] argued that digitalization describes the process by which digital technologies change existing business processes. Autio et al. [18] considered that digitalization is a procedure of applying digital technology to various industries and acting as an infrastructure, which has widely influenced business operations and social life. Bjorkdahl and Holmen [19] identified digitalization as the process of generating, collecting and analyzing data to create value. It offers new features and competitive advantages [20], innovative business models, new revenue streams and opportunities for value creation [21]. A generalization of the previous definitions found that "application of digital technology", "combination of resources" and "impact" are the three main elements in the definition of digitalization [22]. Digitization has four characteristics including presentation, connectivity, aggregation, and interactivity. The advancement in the creation, storage, transmission, and analysis of information makes it possible to enhance the availability of information, through data processing, storage, and transmission at a low cost [23].

2.2. The Impact of Digitalization on Rural Areas

With the increasing application of digital technology, economic and social innovation has been affected in recent years, and digitalization in different regions and industries has been widely discussed [24-25]. Rural digitalization is the utilization of digital technology in the rural areas, which is defined in "The China Digital Countryside Development Strategy Outline 2019" as the derivation of networking, informatization and digitalization in the application of agriculture and rural economic and social development [26]. Rural digital applications and rural digitalization have the functions of reducing organizational and information barriers [27], reducing information asymmetry [28], and achieving precise matching of supply and demand [29]. One of the major elements in the definition of digitalization is the ability of digital technology to have significant impact.

A review of the literature indicated that many scholars believe that rural digitalization plays an important role in the development of rural areas and the improvement of people's living standards. Firstly, rural digitalization promotes agricultural development, improves information availability, information mobility and information forward-thinking decision-making capacity, and changes traditional agricultural business models and profitability [30]. Secondly, rural digitalization assists to achieve social inclusion in rural areas by enhancing modern information skills of farmers [31], and reducing the digital divide between urban and rural areas [32], thereby creating more employment and business opportunities and promoting farmer entrepreneurship [33] [34]. Thirdly, the expansion of digital technologies effectively exploits the potential of rural areas to create modern employment and comfortable living conditions for people [35], as well as sustainable economic growth and improved living standards [36]. Finally, use digital tools to improve rural governance capacity [37], and optimize the allocation of urban and rural public services [38].

2.3. The Impact of Digitalization on Rural Areas

A range of literature has confirmed that ICT has been applied to the tourism industry, including the government scenic and user sectors [39-40]. With the comprehensive integration of digital technology into the tourism industry, the level of digitalization of the tourism industry is continuously improving,

the production methods, experience methods, service methods and governance of tourism are promoted to show digitalization trends [41], and digital technology transforms the tourism industry in an all-round, multi-faceted and whole-chain way to enhance the development efficiency of the tourism industry [42]. According to the literature of tourism industry development practice, digitalization and tourism play a great role in promoting the efficiency of tourism industry, upgrading tourism industry structure and forming innovative tourism business models. Digital efficiency of tourism industry mainly depends on digital technology to accurately predict the demand for tourism consumption, reduce low-end inefficient supply, improve the quality of tourism supply, and achieve sustainable development of tourism industry [43]. To promote the upgrading of tourism industry structure refers to enhancing the personalized experience of tourists and stimulating the generation of new tourism formats. For example, the use of virtual technologies by users for online travel during the COVID-19 pandemic had a positive impact on the level of economic security of the socio-economic system [44-45]. In addition, digitalization triggered a change in the business model of tourism enterprises, which is embodied in the accurate targeting of customers, scientific analysis of customers' needs, redefinition of the tourism products supply chain and innovation of the tourism business model [46].

Digital technology becomes increasingly prominent in the development of rural tourism, scholars from different regions use local empirical cases to demonstrate the connection and interaction between digital technology and rural tourism. For example, Pena's [47-48] [9] presented that ICT deployment is essential for the competitiveness of rural tourism enterprises and that there is an interaction between ICT, market orientation and customer orientation can help to improve the outcomes of rural tourism activities. Sedmak [49] pointed out that the most important factor affecting revenue growth, profitability, organizational climate and customer satisfaction in rural Small and Medium Enterprises (SMEs) is the perception of ICT utilization. Zhu et al. [11] considered that ICT adoption enhances the tourism consumption of rural residents. The evidence from Schuhbauer and Hausmann [13] suggested that ICTs can empower rural tourism, promote rural revitalization and expand the effectiveness of innovative tourism development. By means of digital information technology, the behavior of visitors when shopping has changed. Meanwhile, in the dimension of tourism marketing and promotion, Lucia [50] employed online platforms and case studies to demonstrate that reliance on digital media can have an effective marketing and promotion effect, when visitors post real reviews on blogs. Digital technologies enable digital regulation and governance of the countryside to establish and maintain a sustainable and structured rural tourism ecosystem [51]. Therefore, rural digitalization enhances the management level of rural tourism, improves operational efficiency and tourist satisfaction, reconstructs a new tourism consumption scenario, and accelerates the generation of new business models, modes and products in rural tourism.

Currently, some scholars conducted case studies around the application of digital technologies in rural tourism, and combing through the relevant literature, it is observed that the available studies focus on the importance and function of digitalization for rural tourism. Rural digitalization improves rural tourism management and helps regulatory and governance systems to establish a sustainable and structured rural tourism ecosystem [52], thereby achieving rural resilience, increasing the impact of rural tourism, and reducing income inequality among villagers [53]. Moreover, the widespread use of digital technology increases the efficiency of business operations and tourist satisfaction [54]. Zhou et al. [55] suggested that the digitalization of rural areas reconfigures new scenarios of tourism consumption and accelerates the generation of new businesses, models, and products in rural tourism.

According to the above literatures, digitalization contributes to the continuous upgrading of rural tourism and provides new ideas for the development of rural tourism operations. Nevertheless, the research methods employed in relevant studies are mainly dominated by qualitative evaluation and macroscopic analysis, lacking quantitative analysis and measurement of rural digitalization and rural tourism, and unable to determine the development differences between regions. In addition, most of

the literature is limited to studying the one-way effect of rural digitalization on the high-quality development of rural tourism, and lacks research on synergistic development, and has not clarified whether there is an interaction between the two systems. Therefore, this paper analyzes the integrated development level and characteristics of rural digitalization and rural tourism, taking 253 counties in China as examples. The coupled and coordinated relationship between the two systems is explored, as well as the influencing factors. This study will help policy makers to grasp the development stage and identify problems in order to choose a more appropriate path to coordinate the development of rural digitalization and tourism industry.

3. Methodology

In order to investigate the level of coupled coordination between rural digitalization and rural tourism, a coupling model is used to measure the relationship between the two systems.

3.1. Sample Collection

China leisure agriculture and rural tourism demonstration county (Rural tourism demonstration county) is considered to be an important carrier for the high-quality development of rural tourism in China, where the development level and regional differences objectively and realistically showed the rural tourism development and the level of rural in digitalization China's counties [56]. From 2010 to the end of 2017, China has selected 388 rural tourism demonstration counties (excluding Hong Kong, Macao and Taiwan). In consideration of the fact that the counties of four municipalities directly under the Central Government of Beijing, Shanghai, Tianjin and Chongqing have achieved a high level of urbanization, it lacks comparability with other counties [57]. Meanwhile, according to the hierarchy of administrative regions in China, county-level administrative districts include municipal districts, counties, and county-level cities. Since municipal districts are city-based and are the center of regional economic development, the level of development and digitalization is much higher than other county-level administrative districts [58]. Therefore, excluding the 114 municipal districts, the analysis is conducted for the remaining 253 demonstration counties, accounting for 65.2% of the total number of demonstration counties, covering 27 provinces in China, with the distribution of specific districts as shown in Table 1. The data are provided by the China Rural Statistical Yearbook, the Statistical Bulletin on National Economic and Social Development of National Provinces and Municipalities, the Ali Research Institute and the official websites of provincial and municipal governments and tourism bureaus, referring mainly to 2019 (Latest Data).

Table 1. Province-wise distribution of tourism demonstration counties

Provinces	Number	Provinces	Number
Zhejiang	19	Shaanxi	9
Jiangsu	18	Liaoning	9
Shandong	16	Sichuan	8
Henan	13	Jilin	7
Fujian	12	Guizhou	7
Anhui	12	Gansu	6
Jiangxi	12	Guangdong	6
Guangxi	11	Hainan	5
Xinjiang	11	Qinghai	5
Hebei	10	Shanxi	5
Heilongjiang	10	Tibet	5
Yunnan	10	Inner Mongolia	5
Hunan	10	Ning Xia	4
Hubei	9		

3.2. Variable measurement

Rural digitalization and rural tourism are two separate and mutually influential systems (Martinez et al., 2017), the coupled evaluation index system includes the degree of rural digitalization as well as the level of development of rural tourism. Following the principles of data availability, indicator representativeness and system relevance, this study designs and constructs an evaluation index system, selecting system level, primary and secondary indicators, with a total of 18 variables to illustrate the development of the rural digitalization and tourism industry. Table 2 shows the description of all the variables included in the analysis.

Table 2. Evaluation indicators of the Rural Digitalization and Rural Tourism subsystem

Subsys-tem	First-level indicator	Second-level indicator	Data source	References
Rural Digitalization	Digital Infrastructure	Mobile device access per 10,000 users	AU Data	Peking University New Rural Development Institute [57]
		Digital Financial Infrastructure Index	Beijing University Digital Inclusive Finance Index	
	Economic Digitalization	Number of modern agricultural industrial parks	Official Government Website	OECD [59]; CAICT [60]; Peking University New Rural Development Institute [57]
		Number of national demonstration bases for new industrialization industries	Official Government Website	
		Percentage of Taobao villages among all administrative villages	Taobao Village Report National Bureau of Statistics	
		Number of logistics network points per 10,000 inhabitants	Ali Data	
		Is it an advanced comprehensive demonstration county for rural e-commerce	Official Government Website	
	Governance Digitalization	Proportion of all countryside towns with a WeChat public service platform	National Bureau of Statistics WeChat platform	Wan et al. [61]
		Number of users using Alipay for government services per 10,000 persons	Ali Data	
	Life Digitalization	Online living consumption per capita	Ali Data	Tencent Research Institute [62]
		Number of recorded attractions on online travel platforms per 10,000 people	Ctrip.com	
		Number of doctors from the county registered on online healthcare platforms per 10,000 people	Online medical platforms	
Rural Tourism	Industrial Economy	Rural tourism revenue	Provincial and Municipal Statistical Yearbook	Huang & Peng [63]; Wang et al. [64]; Du et al. [65];
		Number of Rural Tourists	National Economic and Social Development Statistical Bulletin	
	Tourism Resources	National Tourism Important Countryside	Official Government Website	Zhu et al. [66]; Kulgachev et al. [67]
		Number of A Grade Tourist Attractions	Official Government Website	
		Number of Hotels	Online Tourism Platforms	
	Tourism Impacts	Number of social media reviews of tourist attractions	Online Tourism Platforms	Geng et al. [68]
		Proportion of tourism revenue in regional GDP	Provincial and Municipal Statistical Yearbook	

According to the research of Peking University New Rural Development Institute [57], the rural digital subsystem is developed in four dimensions: digital infrastructure, economic digitalization, governance digitalization and life digitalization. Digital infrastructure includes information infrastructure and financial infrastructure, which is measured using the number of mobile device accesses per 10,000 people and the Digital Financial Infrastructure Index published by Peking University, respectively [60]. Economic digitalization includes digital production, digital supply chain management and digital marketing. The level of digital production is judged through the number of national modern agricultural demonstration projects, the number of national new industrialization demonstration bases, and the percentage of Taobao villages, which implies that the demonstration projects accelerate the transformation and industrialization of regional agricultural scientific and technological achievements. The governance digitalization stands for the use of digital means for social governance, advocates the vigorous development of e-government and the construction of a satisfactory rural grassroots information platform, evaluated by means of the proportion of countryside towns that have opened WeChat public service platforms and the number of users using government services per 10,000 Alipay users [69]. The life digitalization represents the usage of digital platforms by residents to complete consumption, travel and healthcare. It is expressed separately in terms of online living consumption per capita, the number of recorded attractions on online travel platforms per 10,000 people, and the number of doctors from the county registered on online medical platforms per 10,000 people [61].

Regarding the indicators of the tourism industry, the seven basic categories are grouped into three primary indicators: tourism industry economy, tourism resources, and tourism impacts. Tourism economy is defined as the income and scale of the tourism industry and includes the total annual income from rural tourism and the total number of tourists [63-65]. Tourism resources reflect the internal composition of the industry and cover the number of tourist attractions [66], number of A grade tourist attractions and the number of hotels [67]. Tourism impact is measured using the number of social media reviews and GDP share of tourism revenue regions, which represents the tourism influence of the region [68].

3.3. Data analysis methods

The research methods involved in this study are as follows.

- 1) Calculate the indicator weights of the 2 sub-systems using the entropy weighting method;
- 2) calculate the combined score of 253 counties using the linear weighting method;
- 3) calculate the coupling coordination degree through the coupling coordination model;
- 4) Clarify the coupling coordination relationship between digitalization and tourism systems through statistical analysis.

3.3.1. Entropy method

The entropy method is an objective method that is widely used in the engineering, social and economic fields. According to the degree of variation of each indicator can be calculated the information entropy, in turn the entropy value is modified for the weight of each indicator to obtain an objective weight. The comprehensive evaluation of primary indicators consists of three steps: Data standardization, calculation of weights and calculation of the combined score.

- 1) Data Standardization. Owing to the magnitude and dimensional differences of the selected data, the data is standardized by the extreme value method. In order to ensure that all the data is meaningful, the dimensionless data are shifted by $X_{ij} = X_{ij} + \partial$ to eliminating zero and negative values. To preserve the properties of the original data to the maximum extent possible to avoid destroying the intrinsic laws of the original data, ∂ is close to the value taken for X_{ij} , and in this paper we take $\partial = 0.001$ and address the formula as in equation (1).

$$X_{ij} = \begin{cases} \frac{X_i - X_{\min}}{X_{\max} - X_{\min}} + 0.001 \\ \frac{X_{\max} - X_i}{X_{\max} - X_{\min}} + 0.001 \end{cases} \quad (1)$$

X_i is the raw data, X_{ij} is the standardized indicator, $X_{\min}$ and $X_{\max}$ are the maximum and minimum values of the sample.

2) Determination of indicator weights. Calculate the proportion: P_{ij}

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

Calculate the information entropy of each indicator: e_j

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

Calculate the non-discrepancy factor: g_j

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

Calculate the weights of the indicators at each level: W_j

$$W_j = \frac{g_j}{\sum_{i=1}^m g_j} \quad (5)$$

3) Calculation of each subsystem score. This study applies a linear weighting formula to calculate the combined assessment score of the 2 subsystems.

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

$U_i (i=1,2,3)$ refers to the i -th subsystem, $i=1,2$ representing the digitalization subsystem and the tourism subsystem, respectively.

3.3.2. Coupling coordination degree model. The concept of "coupling" in physics is a measure of the dependence of two entities on each other [70]. Coupling describes the degree of interaction and influence (i.e. synergy) within a system or between system elements [71]. The coupling coordination degree evaluates whether the internal systems are coordinated with each other in the development process [72]. Therefore, this paper constructs the coupling between the rural digitalization and rural tourism system with reference to the coupling coordination model proposed by Yuan [73].

1) Calculate the degree of coupling (C) [74]

$$C = 2 \sqrt{\frac{U_1 \times U_2}{(U_1 + U_2)^2}} \quad 0 \leq C \leq 1 \quad (7)$$

Table 3 shows the coupling of the different states. U_1 and U_2 indicates the combined score of rural digitalization and rural tourism system respectively.

Table 3. Classification standard of coupling degree types

Value of C	Coupling Types	Value of C	Coupling Types
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0	No coupling	0.50-0.79	Adaptation coupling
0.01-0.29	Low level of coupling	0.80-0.99	Good coupling
0.30-0.49	Anti-coupling	1	High level of coupling

2) Calculate the degree of coupling coordination (D)

$$D = \sqrt{C \times T} \quad (8)$$

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

D denotes the coupling coordination degree of the two systems, taking a range of [0, 1]. T means the comprehensive development level of the rural digital system and the rural tourism system, α and β are pending coefficients. According to the relevant research results, it is proved that the two systems are of the same importance, so $\alpha = 0.5$ and $\beta = 0.5$ are assumed. Table 4 provides detailed classification of the DCC different levels.

Table 4. Classification of coupling coordination degree

Range	Value of D	Coordination Level
Imbalanced (unacceptable)	$0 \leq D < 0.1$	Extreme imbalance
	$0.1 \leq D < 0.2$	Severe imbalance
	$0.2 \leq D < 0.3$	Moderate imbalance
	$0.3 \leq D < 0.4$	Slight imbalance
Transitional coordinated	$0.4 \leq D < 0.5$	Approaching imbalance
	$0.5 \leq D < 0.6$	Barely coordination
Coordinated (acceptable)	$0.6 \leq D < 0.7$	Primary coordination
	$0.7 \leq D < 0.8$	Moderate coordination
	$0.8 \leq D < 0.9$	Good coordination
	$0.9 \leq D < 1$	High coordination

4. Results

4.1. Results of the overall level of the subsystems

Employing the principle of entropy weighting and using equations (3)-(9), this paper calculates the combined development scores of the rural digitalization industry and rural tourism subsystems for the 253 counties across the country in 2019.

4.1.1. Results of rural digitalization subsystem

In general, China's rural digitalization level indicates a clear pattern of higher in the east (0.593), followed by the central region (0.579), and lower in the northeast (0.386) and west (0.360), as shown in Table 5. It clearly illustrates that the high scores of the rural digital composite scores are mainly distributed in the eastern region, especially in Jiangsu and Zhejiang, which both score above the national average of 0.472, 0.776 and 0.690 respectively. The average digitalization score in the central region (0.579) is lower than that in the eastern region (0.593), but some counties in Jiangxi and Hubei have a relatively high level of digital village development. In addition, the western and northeastern regions have lower digitalization scores except for a few capital cities, which suggests that the western and northeastern regions are currently lagging behind in overall digitalization development.

Studying the four primary indicators that affect the digitalization scores, it can be found that the level of development of rural digital infrastructure (76.233) in China is relatively high, followed by the rural life digitalization (50.349), and the economic digitalization (45.039) and rural governance digitalization (49.020) is relatively slow. Furthermore, there is a significant regional variability in the development levels of the four dimensions, chiefly reflected in the large differences between the east and west. From Table 5, the extreme differences of rural digital infrastructure average score

(79.6:81.7:64.9:69.5), rural economic digitalization score (49.0:47.7:41.6:35.9) and rural life digitalization score (54.5:56.1:43.8:41.5) in the eastern, central, western and northeastern regions are 16.8, 7.5 and 12.3, with a smaller difference. In contrast, the extreme difference in the digital score for rural governance (61.6: 57.7: 31.7: 30.4) is quite significant at 29.9. It suggests that the digitalization development gap of rural governance is an important cause of the current digitalization divide in rural China.

Table 5. National average scores for rural digitalization subsystem

Region	Provinces	Rural Digitalization Composite Score	First-level indicator			
			Digital Infrastructure (14.02%)	Economic Digitalization (26.32%)	Governance Digitalization (40.96%)	Life Digitalization (18.70%)
East	Fujian	0.581	75.816	51.444	57.066	55.969
	Guangdong	0.526	71.521	43.496	61.479	43.045
	Hainan	0.481	75.296	37.815	53.279	45.206
	Hebei	0.520	81.894	47.611	42.901	56.740
	Jiangsu	0.690	83.021	58.834	71.582	58.465
	Shandong	0.575	80.612	46.187	61.831	51.070
	Zhejiang	0.776	89.366	57.832	83.070	71.104
East Average		0.593	79.647	49.031	61.601	54.514
Central	Anhui	0.596	80.222	51.910	57.577	57.233
	Henan	0.577	83.227	46.950	58.897	53.375
	Hubei	0.601	82.883	50.328	61.213	53.765
	Hunan	0.516	78.611	46.846	48.222	50.185
	Jiangxi	0.604	85.639	48.485	58.501	60.556
	Shanxi	0.582	79.892	41.815	61.594	61.723
Central Average		0.579	81.746	47.722	57.667	56.139
North East	Heilongjiang	0.336	59.859	42.516	20.750	43.981
	Jilin	0.501	67.504	39.776	57.637	48.281
	Liaoning	0.321	67.443	42.385	16.752	39.127
North East Average		0.386	64.935	41.559	31.713	43.796
West	Gansu	0.417	81.280	36.838	30.605	53.864
	Guangxi	0.389	70.802	45.324	27.742	41.212
	Guizhou	0.529	81.579	42.636	54.740	49.226
	Inner Mongolia	0.343	69.835	35.393	27.354	40.367
	Ningxia	0.351	81.833	33.527	19.909	50.115
	Qinghai	0.274	70.209	29.123	15.232	42.616
	Shaanxi	0.492	78.871	36.943	57.691	40.957
	Sichuan	0.412	64.776	41.530	42.673	36.662
	Tibet	0.089	26.714	25.556	5.406	22.795
	Xinjiang	0.272	68.998	29.430	18.222	37.462
	Yunnan	0.388	69.475	38.350	35.296	40.860
West Average		0.360	69.488	35.877	30.443	41.467
National Average		0.472	74.340	42.551	44.712	48.369

4.1.2. Results of the degree of coupling coordination

In Table 6, in terms of the four divisions, the rural tourism sub-system has the highest composite score in the East (0.151), followed closely by the Central region (0.145), with the West (0.132) overtaking the North East (0.113) to take third place. From the provincial perspective, Zhejiang and Jiangsu remain the top two provinces in China for rural tourism, with scores of 0.282 and 0.206, respectively, in line with rural digitalization rankings. It is surprising that Guizhou, from the western region, became another province with a tourism score of more than 0.2, which may be related to the rapid economic growth of Guizhou's tourism industry in recent years [51], resulting in a higher score for its industrial

economic dimension. Tibet has the last score in China due to the late start of the tourism industry [75]. Moreover, a circumstance deserves to be noted is that there are differences between different provinces in different four regions, with a smaller gap in scores between provinces within the Central (0.08) and North Easter (0.11) regions. There is a relatively large difference in scores of 0.21 and 0.17 between the eastern and western interior provinces.

According to the further analysis of the three sub-dimensions of rural tourism, it can be seen that China's rural tourism industry is the most mature in economic development, with 17.44. The next most developed is the excavation and construction of tourism resources, which received 14.18. The ability to influence the effect of tourism is still relatively weak, earning a score of 9.03. Furthermore, the gap between the industrial economy, tourism resources and impacts of 27 provinces are 44.9, 19.9 and 13.4 sequentially, which indicates the disparity of tourism industry returns in different counties and reflects that the level of tourism economy enables to directly influence the development level of rural tourism.

Table 6. National average scores for rural tourism subsystem

Region	Provinces	Rural Tourism Composite Score	First-level indicator		
			Industrial Economy (37.78%)	Tourism Resources (30.72%)	Tourism Impacts (31.50%)
East	Fujian	0.110	14.389	10.909	7.000
	Guangdong	0.116	17.278	8.890	7.508
	Hainan	0.074	5.548	10.680	6.418
	Hebei	0.126	14.074	15.000	8.612
	Jiangsu	0.206	33.312	13.576	12.197
	Shandong	0.143	19.042	15.761	7.059
	Zhejiang	0.282	46.542	19.288	14.879
East Average		0.151	21.455	13.444	9.096
Central	Anhui	0.155	17.041	19.369	9.813
	Henan	0.114	14.377	13.851	5.407
	Hubei	0.139	19.625	14.003	6.851
	Hunan	0.160	28.589	8.697	8.136
	Jiangxi	0.193	28.401	17.140	10.481
	Shanxi	0.110	15.486	8.470	8.181
Central Average		0.145	20.586	13.588	8.145
North East	Heilongjiang	0.068	5.928	11.255	3.584
	JiLin	0.182	18.648	20.171	15.665
	Liaoning	0.090	5.779	14.959	6.906
North East Average		0.113	10.119	15.462	8.719
West	Gansu	0.140	11.091	19.719	11.897
	Guangxi	0.197	28.121	13.935	15.086
	Guizhou	0.202	28.825	13.803	16.146
	Inner Mongolia	0.102	10.187	13.478	7.079
	Ningxia	0.082	2.781	20.448	2.731
	Qinghai	0.140	6.690	25.246	11.874
	Shaanxi	0.151	20.416	12.498	11.178
	Sichuan	0.113	17.486	7.530	7.490
	Tibet	0.032	1.614	5.379	2.834
	Xinjiang	0.098	11.775	11.808	5.449
	Yunnan	0.199	27.726	17.106	13.384
West Average		0.132	15.156	14.632	9.559
National Average		0.138	17.436	14.184	9.031

4.2. Results of the degree of coupling coordination

The mean of the national coupling degree C and coupling coordination degree D in 2019 are 0.844 and 0.551 respectively, showing an overall outcome of high coupling and low coordination. It suggests that the two subsystems of China are strongly coupled and have a high degree of synchronization, but the systems have been developed separately and have a low degree of coordination. This finding is attributable to the increased level of digitalization that can effectively facilitate the precision operation of the rural tourism industry.

Through statistics and analysis of the 253 counties, as can be seen from Figure 1 and Figure 2, it is found that as many as 67% of the counties are in a state of good coupling, and three counties are able

to achieve high coupling ($C=1$), namely Yixian, Dunhuang and Jianshui. In terms of coupling coordination, there are 30% of districts that are barely coordination level, followed short by approaching imbalance counties at 27%. In terms of D values, 30% and 27% of counties are in barely coordination and approaching imbalance, covering more than half of the country. In addition, there are three counties in the high coordination and severe imbalance stages, respectively, accounting for 1% of the total sample. Anji and Deqing from Zhejiang and Kunshan from Jiangsu both have coupling coordination values (D) above 0.9, and have achieved high quality integration of digitalization and tourism industry. Whereas, Suo, Mankang and Baxu in Tibet rank as the three counties in China where the digitalization of rural areas is severely dysfunctional with the tourism system, all with D values less than 0.2.

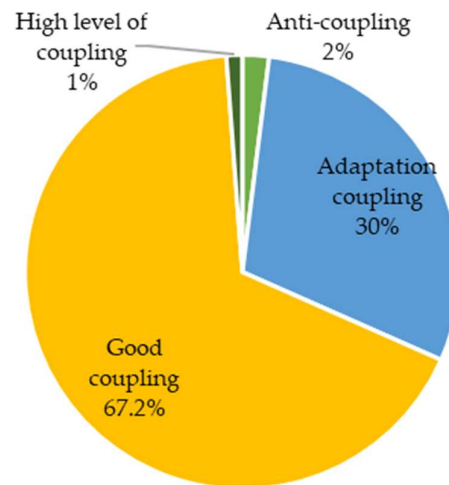


Fig. 1. Distribution of coupling degree

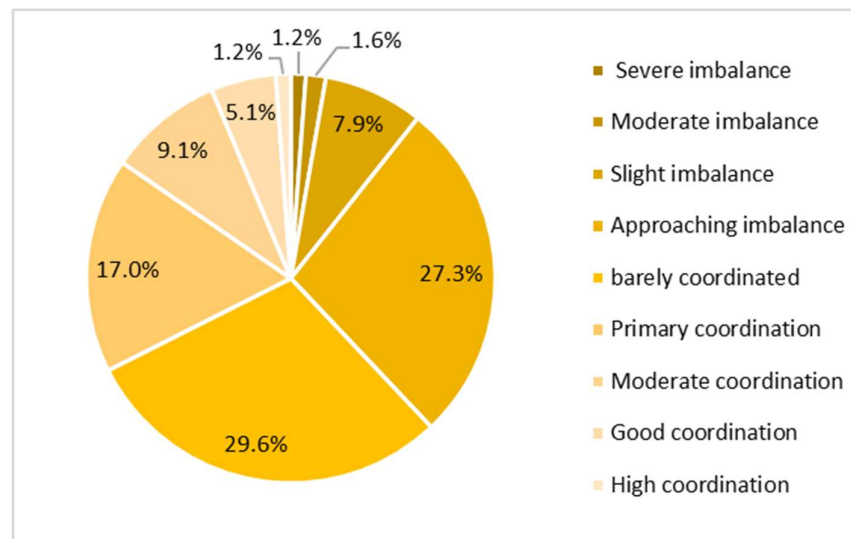


Figure 2 Distribution of coupling coordination levels

Generally, the average coupling coordination degree of China's rural digitalization and rural tourism industry is 0.551, and more than half of the provinces are in Barely coordination stage. It is shown in Figure 3 that the coupling coordination level shows obvious east-west differences, with counties with high D values mainly concentrated in the eastern coastal region, such as Zhejiang (0.753), Jiangsu

(0.647) and Shandong (0.601), and a small number of central regions in the central and western regions, like Jiangxi (0.618) and Guizhou (0.621). Some provinces in the northwestern region have lower levels of coupling coordination, including Heilongjiang, Liaoning, Inner Mongolia, Qinghai, Xinjiang and Tibet. On the basis of the spatial distribution pattern of the coupling coordination degree, according to the average level of the four divisions of China, the East (0.610) > Central (0.572) > West (0.499) > North East (0.468), the regional system coupling coordination level presents certain spatial clustering characteristics.



Fig. 3. Coupling Coordination of China's Province

In the perspective of sub-provinces, as shown in Figure 4, it is noted from the percentage of counties with different levels of coordinated development of rural digitalization and rural tourism in each province in 2019 that 10.5% and 15.8% of the participating counties in Zhejiang are at a high level and a higher-level stage of coordinated development, and the above-mentioned ratios in Jiangsu Province are respectively 5.6% and 22.2%. In Gansu, Jiangxi, Hubei, Hunan and Guangxi, the percentages of counties in good coordination are 16.7%, 16.7%, 12.5%, 10.0% and 9.1%. In addition, except for the western and northeastern provinces where the level of coupling coordination is low, 20.0% of counties in Hunan and Hainan are both at the stage of mild imbalance.

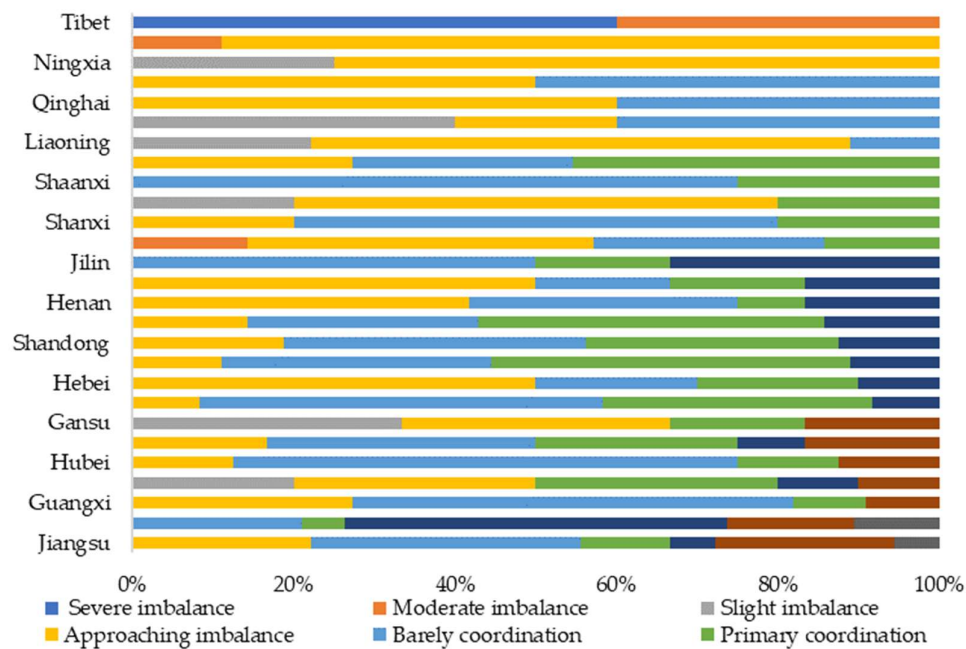


Fig. 4. Number of counties with different levels of coupling coordination by province

5. Discussion

5.1. Analysis of rural digitalization and rural tourism subsystem

From the results of this study, there is a distinct East-West gap in the digitization development of China's rural counties, which exhibits a pattern of faster development in the eastern region, followed by the central region, with the northeastern and western regions lagging behind. The gap between the highest and lowest rural digitalization scores exceeds 0.9 (Table 5), indicating the existence of a regional digitalization divide. The large difference in rural governance digitalization subsystem scores is the main reason for this situation, therefore, the northeast and western regions need to speed up the digital capacity of rural governance [76] and increase the policy inclination towards regions falling behind [77] to reduce the gap between areas. Furthermore, Zhejiang in the eastern region is ahead of other provinces in all four aspects, especially in the basic level of digitalization development, which is significantly related to the favorable internal and external environment of the digital economy. Since digital development requires a large investment of resources, and the Zhejiang government and enterprises are relatively well funded, the overall level of rural digitalization is higher in Zhejiang province. The central provinces, such as Jiangxi, Anhui and Hubei [78], have been improving their rural infrastructure and developing their rural e-commerce industry, which has to certain extent contributed to the digital transformation of the countryside.

In China, there are also regional differences in the level of development of rural tourism, but the gap is smaller than that for rural digitalization, at around 0.6 (Table 6). It is explained by the fact that China has proposed to vigorously promote rural tourism in 2015, earlier than the rural digitalization strategy, which has already gained ground after recent years of construction. Moreover, a further segmentation of municipalities within the region found that the difference in overall tourism scores between different counties in the same province remained large, for example, Anji (0.58) and Songyang (0.11) in Zhejiang. To understand this contradiction, we analyzed the raw data and summarized that the skewed government resources and the difference in the cultural level of the inhabitants account for this result, which is also evidenced in Rasoolimanesh's [79] study. It is also observed through comparison that the tourism resource scores and tourism impact scores of the four regions are closer, while the East and Central regions outperform the other two regions on the industrial economy dimension.

Thereby, it reflects that the rural industrial economy is the most significant factor contributing to rural tourism, which is consistent with the findings of Tang [74] and Wang et al. [64]. In addition, Qinghai and Ningxia are unexpectedly the two provinces with the highest scores in the tourism resource system, because of their excellent natural conditions and rich landscape resources, as well as their significant investment in landscape development and design, thus producing many famous tourist attractions [80].

5.2. *Analysis of coupling between rural digitalization and rural tourism*

There is a noticeable coupling between the rural digitalization and the development of rural tourism, and the two systems interact and influence each other. In accordance with the present results, previous studies have demonstrated that digital technology plays a crucial role in the development of rural tourism [7] [11]. The digitalization of rural tourism can expand the impact of rural tourism and promote high-quality development of rural tourism. At the same time, the transformation of rural tourism drives the digital upgrading of rural villages, introducing diversified digital products and deepening the application of information technology [12]. The current level of coordination between rural digitalization and rural tourism in China is at a barely coordination stage, which has a huge potential for coordinated development. It is likely due to the different starting times and unmatched development stages of rural digitalization and rural tourism in China. The rural digitalization strategy was proposed later and is currently focused on infrastructure construction, serving the livelihood of residents and agriculture, and this coincides with our results. As reported by Zhang [30], the primary objective at this stage is to improve the data resource infrastructure of the digital countryside through 'new infrastructure', as well as to support and balance the construction of a smart village with the digitalization of agriculture. In addition, Luo and Zeng [81] pointed out that some rural tourism landscape resources in China have not been explored, as well as people lack digital awareness and initiative, which will affect the integration of digital technology and tourism to some extent. Hence, the two systems maintain a relatively independent condition of development and are weakly correlated.

The degree of coupling and coordination of rural digitalization and rural tourism development in China presents obvious spatial differences, with higher coupling and coordination in the eastern coastal provinces and lower coupling and coordination in the northwestern provinces. It is attributed to the large differences in location conditions, economic development levels, tourism resources and policy support among provinces and municipalities. Similar to the findings of Feng et al. [82], the level of living infrastructure in the central and western regions of China is significantly lower than that in the East, which may undermine the coordinated rural development in some aspects. Kunshan and Anji manage to be two counties whose industries are highly coupled representative of China because their economic structures, modernization levels, and public service levels such as education, health care, and social security are at the leading position in China [83]. It provides the basis for industrial integration and the formation of a high-quality path in the countryside. Therefore, in order to improve the coordination of rural digitalization and rural tourism, it is necessary to take into account the level of economic development, tourism resources and relevant policies of each country, and adopt relevant strategies adapted to local conditions to achieve a good synergy performance.

5.3. *Innovation and Limitation*

The innovation of this paper aims at the comprehensive analysis of rural digitalization and rural tourism, and constructs two systematic evaluation index systems that could be extended and applied to rural areas of other countries. Meanwhile, the tourism impact is incorporated into the rural tourism system to provide a new perspective for the construction of sustainable development of rural tourism. Furthermore, this study utilizes a coupled coordination model to analyze the bilateral feedback mech-

anism between the two systems, which expands the methodological system of the relationship between variables and provides a deeper grasp of the differences between digitalization and tourism development in the region.

First, as the limitation of data and inadequate knowledge, the currently selected secondary indicators depend largely on the existing national or provincial and municipal statistical calibers and data, and there are some enterprise-level indicators that are not available, hence it cannot fully reveal all aspects of digital transformation in rural areas. Second, this paper proposes a model of coupling and coordination between rural digitalization and rural tourism systems, which similar studies have not been conducted in other parts of the world, resulting in the inability to compare domestic and international longitudinal and cross-sectional dimensions. Lastly, the reasons that constrain development and generate coupling incoherence in different provinces is also to be explored in depth. These issues will be further explored in our future research.

6. Conclusions and Implication

6.1. Conclusion

This study constructs a coupling evaluation index system and a coupling evaluation model for two major systems from the perspective of the interaction between rural digitalization and rural tourism. The development and coupling degree of rural digitalization and tourism are calculated and evaluated for 253 demonstration counties in China. It is intended to provide an in-depth analysis of the principles of mutual influence and coordinated development of the two systems in rural China. The main findings of this research might be summarized as follows.

Firstly, variation in the level of rural digital development between counties is greater than that of the rural tourism industry. Secondly, there is a high degree of coupling between rural digitalization and rural tourism, and the rural tourism industry is in a position to play a tractive role, whilst the digitalization framework acts as a promoter, with the two systems mutually affected. Thirdly, the two systems are in Barely coordination stage in most counties in China, which has substantial room for improvement. Finally, there are regional differences in the degree of coupling and coordination of the two systems, featuring a distribution of divergence at a two-end and convergence in the middle between provinces. Specifically, the coupling coordination degree is the highest in the eastern coastal region, the coupling coordination in the central and western inland regions is in the middle, whereas the coordinated development level in the northwestern region falls behind.

6.2. Theoretical implication

The theoretical contributions of this paper are mainly in the following aspects. First, we expand and increase the empirical data by adopting 253 rural villages in China, it enriches the study of rural digitalization in the rural tourism industry and deepens the understanding of the relationship between the two systems. Secondly, quantitative research has been carried out on the degree of coupling between the two systems of rural digitalization and tourism. This approach could be applied to examine the degree of coupling and coordination between the tourism industry and the digitalization process in different cities and cycles.

6.3. Practical implications

The results of the study provide several important implications for the digitalization development and tourism in rural China. Firstly, the rural management authorities are supposed to make enhancing the governance digitalization as the primary task of building rural digitalization, strengthen the coordination, organize the plan around the important role of digital technology in grassroots democracy, social security, mobile population management, social security, and enrich the specific scenarios of digital

technology application in rural governance. At the same time, the capabilities of the rural industrial economy play an important role in the development of rural tourism. The related departments need to work based on the characteristic resources of local areas, strive to expand multiple functions of the countryside, pay attention to the integration of resources from all sides, establish core industries, and stimulate rural economic returns.

Secondly, the coupling and coordination level of China's rural digitalization and rural tourism cooperation is still at the Barely coordination stage. In order to improve the level of coupling and coordination between the two systems, the government should continue to introduce a series of policy measures to promote the effective integration of rural digitalization and tourism development, including industrial planning, platform construction, and product design. Additionally, the government continually enhances infrastructure construction in economically poorer areas, builds a complete and real-time database of rural tourism resources, expands new spaces for rural tourism, and improves accessibility for tourists. For regions with lower levels of digital development, it will increase investment in construction funds and talents to balance the development of each region. Through the intelligent transformation of the tourism industry, the application of digital technology can be expanded to bring new demand for rural tourism. The digital benefits of tourism products would feed into the digitalization of the rural areas, thereby promoting a coordinated partnership.

Finally, for developing countries, especially China, the relevant authorities put emphasis on coordinated regional development and continue to promote coordinated rural development among the four major regions and provinces. In particular, they will focus on improving farmers' income and agricultural modernization in the west and northeast regions, striving to eliminate differences in rural governance, social security, medical and health care, and consumption, and preventing the expansion of gaps in tourism resources and ecological environment as well. On the one hand, the eastern coastal regions should keep extending the application of digitalization products in the tourism industry to expand the industry's advantages and perform as a demonstration. On the other hand, for the central and western regions, the government should invest substantially in digitalization infrastructure, including transportation, storage and logistics. Drawing on the experience of the East Coast region, the priority is to encourage the construction of rural counties with distinctive tourism resources, introduce intelligent platforms and establish regional popular attractions to ensure that the advantages of the resources are effectively utilized and the industrial structure is gradually optimized.

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