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Coupling Sensitivity and Sensing Model between Culture and Tourism Systems

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Cultural resources and the tourism industry are two major systems that are mutually inductive and restrictive. It is of great significance to correctly understand the sensitive relationship between them and make full use of a smart tourism data platform to build a coupling coordination sensing model of cultural tourism. In this paper, an evaluation index system for cultural resources and the tourism industry is constructed by taking 13 cities of Jiangsu in China as the study area, and the sensitivity between the two major systems is evaluated by using a combination of the information entropy weight (IEW) method and a coupling coordination degree model (CCDM). Using data on culture resources and the tourism industry in Jiangsu from 2009 to 2019, we analyzed the comprehensive development level as well as the coupling coordination characteristics of the two major systems from the perspective of spatiotemporal heterogeneity through big data analysis with the help of the Geographic Information System (GIS). It was concluded that the comprehensive development level of the two major systems has increased over time. The ecological culture and development support subsystems had the greatest contribution to the culture–tourism coupling system. The annual average coordination degree of each city has developed steadily to a high level while exhibiting a significant spatial dependence and a spillover effect. The sensing model in this study can be an important reference for culture and tourism development.

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1. Introduction

Culture is the sum of material and spiritual wealth jointly created by all humankind, and is also at the core of tourism development. Cultural resources and the tourism industry have a natural symbiotic coupling relationship. Cultural resources are the driving force promoting the development of the tourism industry, and the tourism industry is the organic carrier of cultural resource inheritance. Different cities differ in the development and utilization of cultural resources in regional tourism development. Abundant cultural resources do not mean a developed tourism industry. Objectively evaluating the sensitivity of regional cultural resources to the tourism industry and exploring their coupling and coordination sensing model can help the two systems to couple and interact more effectively and provide a decision-making basis for the sustainable and high-quality development of culture and tourism.

The study area in this paper is Jiangsu, located on the east coast of China, near the lower reaches of the Yangtze River and Huaihe River and adjacent to Shanghai in the south. Jiangsu has a profound cultural heritage and is the origin of the Yangtze River culture in ancient China.(1) The 13 major cities in the region are rich in cultural resources, including world cultural heritage sites such as Suzhou Gardens, Ming Xiaoling Mausoleum, and China's Grand Canal, and world intangible cultural heritage sites such as Yunjin, Kunqu opera, and paper cutting. Abundant cultural resources have contributed to the development of the tourism industry in Jiangsu province. There are regional differences in the coordinated development level of industrial agglomeration and urbanization(2) and significant differences in the development of the tourism industry in different regions. Suzhou, located in the south of Jiangsu, is rich in traditional cultural resources and has a developed tourism industry. Changzhou, despite relatively few cultural relics, also has a strong tourism industry. Huai'an, located in the north of Jiangsu, has rich historical and cultural heritage but the tourism industry is relatively backward. The diversity of cultural resources and the differences in tourism industry development make Jiangsu a suitable case for this study (Fig. 1). The combination of the coupling coordination degree model (CCDM) and the information entropy weight (IEW) method for evaluating intersystem sensitivity is applied in the study(3) to comprehensively evaluate the sensitivity relationship between cultural and tourism systems in Jiangsu.

2. Literature Review

Culture is the material and spiritual wealth created in human social practice, which can be exploited and utilized by modern social and economic activities. The research on the relationship between cultural resources and the tourism industry is gradually deepening. Scholars worldwide have discussed the interaction between culture and tourism from the perspective of cultural tourism. Syafrini *et al.* studied how Sawwahlunto, Indonesia, reused mining cultural heritage resources to develop tourism, making it a successful mining tourism city and avoiding the threat of urban decline.(4) Artal-Tur *et al.* analyzed the leading role of cultural activities in attracting long-distance and first-time tourists to Spain.(5) Connell pointed out that movies and other cultural media have a major influence on tourism flows.(6) Ranwa took Kalbeliya, an intangible

Fig. 1. (Color online) Location of Jiangsu.

cultural heritage in India, as an example to demonstrate the profound impact of tourism on intangible cultural heritage.[7]

2.1 Application of advanced sensing in smart tourism

Smart tourism systems, a product of the information and Internet ages, are an important embodiment of the in-depth implementation of a scientific approach to development.[8] A smart tourism system refers to the comprehensive, thorough, and timely perception of geographical aspects of scenic spots, natural resources, tourist behaviors, staff movements, infrastructure, and service facilities through an intelligent network, as well as the visual management of tourists and staff[9] so as to achieve comprehensive, coordinated, and sustainable developments of the environment, society, and economy. Table 1 shows the application modes of modern smart tourism sensors.

2.2 Data coupling analysis

With the development of information and communication technology, the use of the Internet continues to increase, resulting in the growth of the volume of data on the Internet and the emergence of the concept of big data.[15] In the network information environment, tourists need systematic and massive online tourism information to support their decision-making.[16] The development of the traditional tourism industry urgently needs digital technology to reduce costs and improve efficiency.[17] Del Vecchio *et al.* pointed out that in the context of smart tourism, the marketing of tourist destinations can be solved by digital technology.[18] Joo *et al.* clarified that advanced information technology and ubiquitous sensor networks can be used to protect cultural

Table 1
Application of advanced sensing in smart tourism.

Dimension	Application technology
Intelligent scheduling	Combines the product capabilities of mobile video communication, 5G inspection, and two-way radio with big data analysis to realize real-time image transmission and remote accurate control.
Intelligent monitoring	Realizes monitoring,[10] information release, hot spot annotation, emergency plans, emergency drills, and other functions through the platform. Real-time acquisitive information on changes in green resources, infrastructure, and tourist flows at scenic spots through video surveillance cameras, RF identification, IR sensing, and laser scanning.
Mobile applications	Online booking, QR code recognition, online guidance, online applications for repair, personnel positioning, information release, online payment, online complaints, equipment inspection, online order delivery, photo identification, information queries, etc.[11]
Virtual reality	AR intelligent guide, navigation. Maps and promotional materials are processed by AR technology and presented in the forms of video, music, and animation. Landmarks or unique sights are identified to enhance and highlight the theme of the site.[12]
Equipment management	AIoT technology is adopted to realize the interconnection, location positioning, data monitoring, state supervision, and timing collection of assets in scenic spots (equipment, parking management, access control management, face recognition, smart light poles, infrastructure, etc.), thus achieving intelligent management of assets.[13]
Integrated management	Management of platforms of data collection, data processing, data analysis, data visualization, intelligent security, user portraits, public opinion monitoring, passenger flow analysis, etc.[14]

heritage resources so that tourists can easily travel to cultural heritage sites by using cultural network applications.[19]

In terms of coupling analysis, Wang *et al.* discussed the spatiotemporal coupling changes and characteristics of Huaihe River by using water resources data of the Ecological Economic Belt from 1998 to 2018.[20] Hong *et al.* studied the coupling coordination and compensation model of urban cultural resources and the tourism industry in the Yangtze River area.[21] In general, studies on the coupling coordination of cultural resources and the tourism industry are gradually becoming more in-depth. In contrast, coupling sensitivity and sensing models of the two systems are relatively lacking. Using Jiangsu as a case, this study explored the dynamic trend of the coupled development of the two systems, identified the indicators that contribute to the subsystems, improved the theoretical system of culture and tourism development research, and promoted the high-quality merging of the development of culture and tourism.

3. Research Method

The CCDM combined with the IEW is an effective method for evaluating the sensitivity between systems.

3.1 Construction of evaluation index system

The design of an evaluation index system is the basis for studying the coupling coordination degree between regional cultural resources and the tourism industry. The premise of the analysis

is to construct a rational and comprehensive evaluation index system. According to the principles of data availability, representativeness, measurability, and systematic relevance, and on the basis of the previous literature, the indices are divided into two systems: cultural resources and the tourism industry. Cultural development is inseparable from the natural ecological environment. Under the background of ecological priority and green development, more attention should be paid to the ecological environment. Therefore, the "ecological" index is added on the basis of the widely used cultural resource index "material culture and non-material culture". The cultural resource system mainly includes material culture, intangible culture, and ecological culture, while the tourism industry system mainly includes the market scale, economic benefit, and development support. Eighteen specific indicators are selected (Table 2). The data are taken from statistical yearbooks of cities, government reports, regional intangible cultural heritage networks, and lists published by regional cultural heritage administrations from 2009 to 2019, including China Statistical Yearbook, China Urban Statistical Yearbook, China Tourism Statistical Yearbook, and Statistical Bulletin of National Economic and Social Development. The research period from 2009 to 2019 is selected mainly because the continuous data over ten recent years can better explore the induction rule between the two systems, laying a solid foundation for the construction of a coupling coordination sensing model and the development of cultural tourism. In 2020, the COVID-19 pandemic broke out and the tourism industry was basically stagnant, so data from this year are not suitable for inclusion in time series analysis with pre-epidemic data. Owing to the different standards of the selected index data, there are differences in the dimension and magnitude between the data. Range standardization is used for data processing, and missing values are supplemented by interpolation.

Table 2
Development index of cultural resources and tourism industry.

System	First-class index	Second-class index
Tourism industry	Market size	Number of domestic tourists
		Number of inbound tourists
	Economic benefit	Contribution of tourism to GDP
		Domestic tourism revenue
		Foreign exchange income of tourism
	Development support	Number of star hotels
		Number of travel agencies
		Number of tourist attractions
		Number of accommodation and catering workers
Cultural resources	Material culture	Number of national cultural heritage sites
		Number of provincial cultural heritage sites
		Number of libraries
		Number of cultural centers
		Number of museums
	Intangible culture	Number of items of national intangible cultural heritage
		Number of items of provincial intangible cultural heritage
	Ecological culture	Number of national nature reserves
		Number of national scenic spots
		Number of national geological parks
		Number of national forest parks

3.2 Evaluation methods

3.2.1 IEW

The IEW method can use the statistical properties of the selected indicators to determine their weights, which can effectively avoid the subjectivity of the analytic hierarchy process (AHP) or Delphi method in the weighting process. Therefore, this method is adopted to measure the level of cultural resources and the tourism industry. For specific steps, refer to the relevant literature.[22]

3.2.2 CCDM construction

In this study, the degree of interaction and mutual influence between the two systems is called the coupling coordination degree. It consists of three parts: the classification system and discriminant standard of the degree of development (T), the degree of coupling (C), and the degree of coordination (D).

$$T = \alpha u_1 + \beta u_2 \tag{1}$$

$$C = 2\{(u_1 \times u_2)/(u_1 + u_2)^2\}^{1/2} \tag{2}$$

$$D = \sqrt{C \times T} \tag{3}$$

Here, T represents the comprehensive evaluation index of cultural resources and the tourism industry used to reflect their comprehensive benefits and α and β represent undetermined weights. Since cultural resources and the tourism industry complement each other, both α and β are assigned a value of 0.5. u_1 and u_2 represent the cultural resource index and tourism industry index, respectively. C denotes the coupling degree of the two systems. In physics, the phenomenon that two or more subsystems in an open system interact, influence, and promote each other based on a particular connection to lead to collaborative evolution is known as multisystem coupling coordination theory. D is the square root of the product of C and T, and reflects differences in coupling coordination level.

The coupling degree reflects the degree of interaction of the system, and the coordination degree reflects the coordination of the coupling degree. Referring to previous studies on the correlation levels of the coupling and coordination degrees, we divide the coupling and coordination degrees of the two systems into five levels by using a uniform distribution function (Table 3).

Table 3
Levels of coupling and coordination degrees.

Coupling degree (*C*)	Coupling level	Coordination degree (*D*)	Coordination level
0–0.20	Highly decoupled	0–0.20	Serious disorder
0.21–0.40	Decoupled	0.21–0.40	On the verge of disorder
0.41–0.60	Low coupling	0.41–0.60	Moderate coordination
0.61–0.80	Moderately coupled	0.61–0.80	Favorable coordination
0.81–1.0	Highly coupled	0.81–1.0	Strong coordination

4. Results and Analysis

4.1 Analysis of coupling degree

The overall development level of the tourism industry system in Jiangsu has shown an upward trend, rising from 0.18 in 2009 to 0.33 in 2019 (Fig. 2). As shown in Fig. 2, the comprehensive development level of tourism dropped slightly from 2012 to 2013 because the number of inbound tourists and the foreign exchange income from international tourism decreased in that year. Since 2013, tourism-related departments have optimized their statistical calibration and methods by considering the number of overnight inbound tourists counted by public security departments to avoid double-counting data from various cities.

The government of China has successively issued relevant laws and regulations to promote tourism development and a series of industrial support policies. The favorable policy environment has further boosted the development of the tourism industry. Among the influences on the comprehensive development level of the tourism industry, the development of the supporting subsystem has been the greatest.

The comprehensive development level of the Jiangsu cultural resource system is correlated with the tourism industry system and also shows an overall upward trend. The comprehensive development level increased from 0.22 in 2009 to 0.30 in 2019 (Fig. 3). In 2012, the material culture subsystem level increased, which is closely related to the country's increased construction

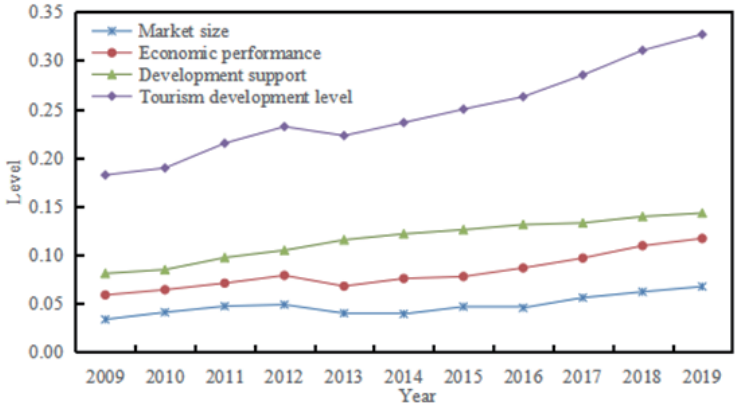

Fig. 2. (Color online) Comprehensive development level of the tourism industry in Jiangsu.

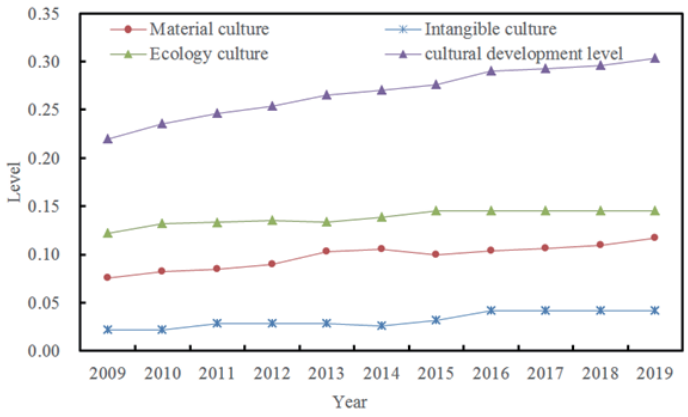

Fig. 3. (Color online) Comprehensive development level of culture in Jiangsu.

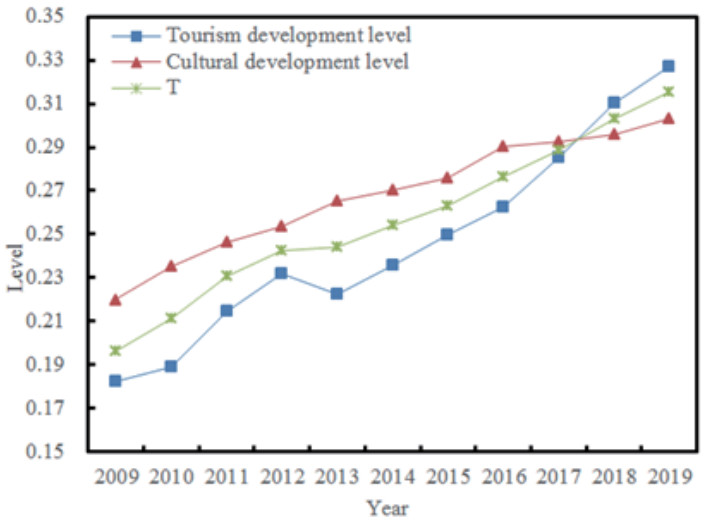

Fig. 4. (Color online) Development level of tourism and culture in Jiangsu.

of public cultural service facilities. As early as 2007, the government of China put forward the goal of ecological civilization construction. Cultural development is inseparable from the natural ecological environment, and the ecological and cultural subsystems have the greatest influence on the comprehensive development level of the culture.

According to the coupling development trend of the tourism industry and cultural resources in Jiangsu (Fig. 4), the comprehensive evaluation index of cultural resources before 2016 was higher than that of the tourism industry, indicating that the tourism industry lagged behind the development of cultural resources from 2009 to 2016 and did not give full play to the advantages of regional cultural resources. Since 2016, China has paid equal attention to cultural tourism and leisure tourism, promoted both traditional and new forms of tourism, and improved infrastructure construction and tourism public services.

Tourism has been integrated into the overall economic and social development and has become a strategic pillar of the national economy. The comprehensive evaluation index of the

Jiangsu tourism industry was higher than that of cultural resources. The tourism industry developed faster than the utilization of cultural resources, and the gap has tended to expand. The effective development and utilization of cultural resources have become important factors affecting the development of the tourism industry.

4.2 Analysis of coupling coordination degree

From the coupling degree (Fig. 5), the annual mean values of all 13 cities are between 0.9 and 1, indicating a high degree of coupling and a strong correlation between cultural resources and the tourism industry.

The level of tourism development in Changzhou and Nantong exceeds the level of cultural resource development. That is, tourism development does not completely depend on the cultural resource endowment; the culture resources development level of Zhenjiang is comparable to that of Huai'an, but there is a gap in the development level of the tourism industry. The development of the tourism industry in Huai'an lags behind that of cultural resources, showing that the cultural resources in Huai'an are not being fully utilized for tourism development. This phenomenon shows that although there is an inductive correlation between cultural resources and the tourism industry, it is not consistent. The role of cultural resources in the tourism industry is also affected by other factors, such as information communication.

On the basis of the coupling coordination degree data of cultural resources and the tourism industry in the Jiangsu cities in 2009 and 2019, the spatial differentiation characteristics of coupling coordination between cultural resources and the tourism industry are demonstrated using the natural fracture point method of ArcGIS (Fig. 6). The geographic information system (GIS) is a specific and important spatial information system. It collects, stores, manages, calculates, analyzes, and describes geographically distributed data in space using computers. In

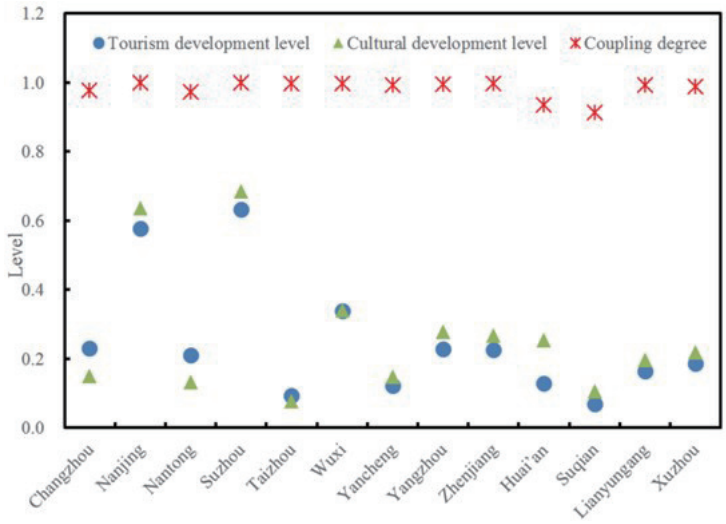

Fig. 5. (Color online) Comparison of the average comprehensive development level and the coupling degree of tourism and culture in 13 cities of Jiangsu from 2009 to 2019.

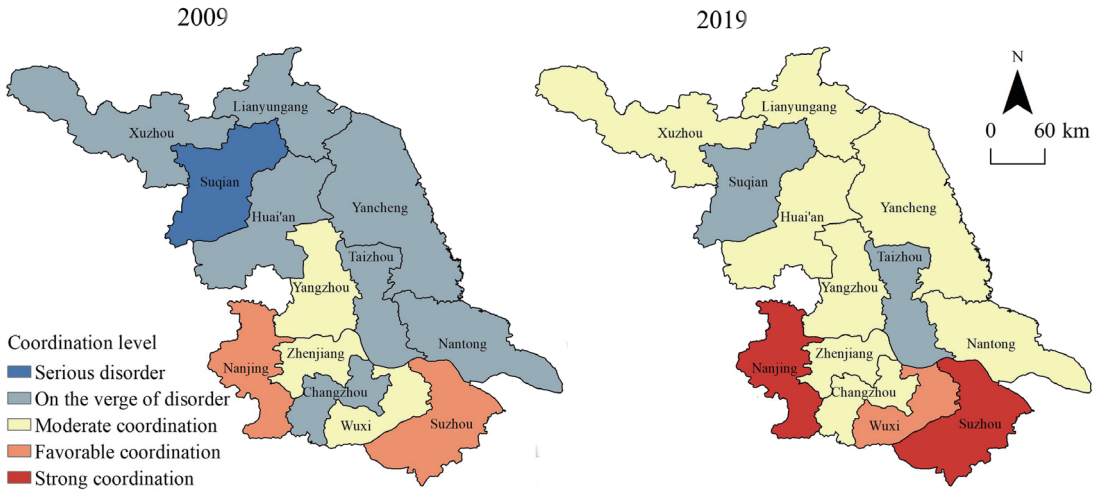

Fig. 6. (Color online) Spatial differentiation of coordination degree between cultural resources and the tourism industry in Jiangsu in 2009 and 2019.

general, the coordination degree of cultural resources and the tourism industry in Jiangsu has improved over time, but the development is not balanced. Coordination and interaction developed steadily to a high level, and the types of coordination gradually changed from serious disorder, on the verge of disorder, moderate coordination, and favorable coordination to on the verge of disorder, moderate coordination, favorable coordination, and strong coordination (see Table 3 for definitions), presenting a spatial distribution pattern of high coordination in southern central cities and low coordination in the northwest of Jiangsu. The coupling coordination degree of Nanjing and Suzhou has always been the highest. Geographically, Nanjing is located in the core of the Nanjing City circle, while Suzhou is subordinate to the Shanghai City circle. This shows that the siphoning effect with a higher coordination degree is affected by distance, traffic, information flow, and economic factors. In terms of the spatial distribution, Fig. 6 generally shows the spatial characteristics of "high in the east and low in the west" in the east–west direction and "high in the south and low in the north" in the north–south direction, indicating a significant spatial dependence and a spillover effect.

5. Coupling Coordination Sensing Model of Cultural and Tourism Systems

There is a strong coupling between cultural resources and the tourism industry in Jiangsu, but the coordination degree is low. From 2009 to 2019, the coordination degree of the two systems in Jiangsu gradually improved, increasing from 0.4096 in 2009 to 0.5365 in 2019. However, the rate of development was low and the coordination remains moderate. Under the background of the new rapid development stage, an unbalanced and inadequate regional development is still prominent and the coupling coordination sensing model is relatively absent. The discussion of the coupling coordination sensing model of cultural resources and the tourism industry (Fig. 7) is conducive to the high-quality development of culture and tourism.

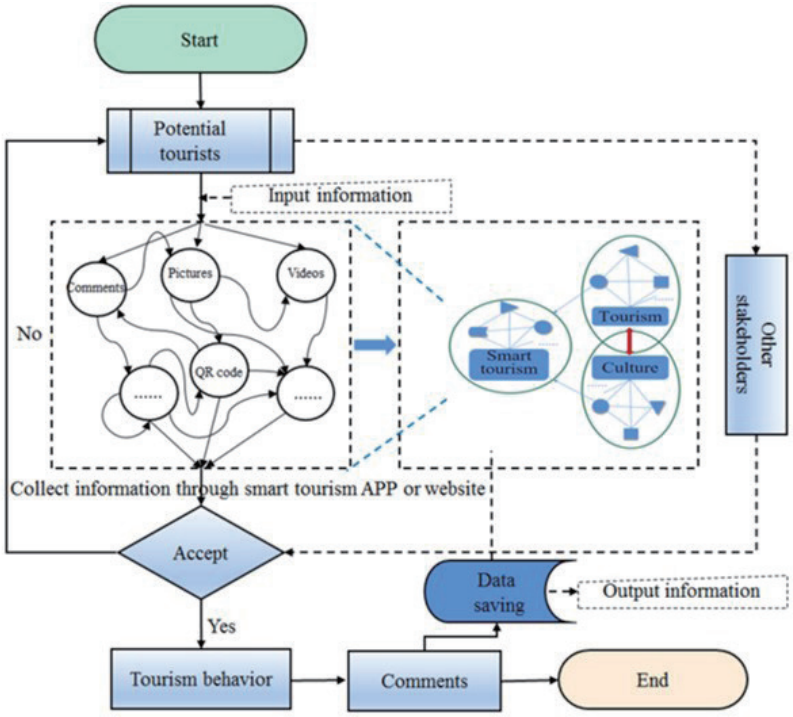

Fig. 7. (Color online) Coupling coordination sensing model of culture and tourism.

Under the background of the information age, potential tourists receive relevant cultural and tourism information data from a big data platform before making decisions, they collect information through the smart tourism big data platform, then they transform it to actual tourism behavior, output a large amount of feedback information, and influence the next cycle through the feedback of the smart tourism big data platform.

6. Discussion

On the basis of the panel data of 13 cities in Jiangsu from 2009 to 2019, the cultural resource and tourism industry levels were analyzed, and the spatiotemporal coupling coordination characteristics and a high-quality development sensor model are discussed. From the perspective of time trends, the mean of the comprehensive evaluation of cultural resources and the tourism industry of the cities in Jiangsu increased gradually year by year from 2009 to 2019, and the tourism industry lagged behind the development of the cultural resources from 2009 to 2016. After 2016, the comprehensive evaluation index of the tourism industry system was significantly higher than that of the cultural resource system. The tourism industry in Jiangsu has developed faster than the utilization of cultural resources. The coupling degree showed an upward trend with a small drop in 2012–2013. From the perspective of the spatial distribution, the coupling coordination degree of cultural resources and the tourism industry in Jiangsu has improved with time and the overall average coordination degree is moderate, but the development is not

balanced. This shows the spatial characteristics of "high in the east and low in the west" in the east–west direction and "high in the south and low in the north" in the north–south direction, with a significant spatial dependence and a spillover effect.

7. Conclusion

It was found in this study that the culture resource and tourism industry systems influence and promote each other. Specifically, cultural resources not only provide the foundation for the development of the tourism industry but also act as the driving force to promote its development, while the development of the tourism industry not only promotes the protection and utilization of cultural resources but also acts as an organic carrier of cultural resources. Culture and tourism influence and promote each other, and the convergence of the two is an inevitable trend.[23] Note from the data analysis that the existence of a relatively strong inductive correlation between the cultural resource and tourism industry subsystems in some areas does not necessarily mean that they are consistent. The role of cultural resources in the tourism industry is also affected by other factors, such as government policies, information, and communication. Furthermore, the eco-culture and development support subsystems are the subsystems most sensitive to the culture–tourism coupling system.

In the context of the new era, the importance of smart tourism big data platforms should be brought into play, and a coupling coordination sensing model of cultural resources and the tourism industry should be constructed in an interdisciplinary manner to realize effective data sharing and promote the high-quality development of culture and tourism.

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