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Article

Spatio-temporal evolution of coupling coordination degree between urbanization and tourism industry: A case study of rural revitalization strategy of the Wuling Mountain area in central China

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Abstract: China is currently at a critical juncture in implementing the rural revitalization strategy, with urbanization and tourism development as crucial components. This study investigates 41 counties (cities) in the Wuling Mountain area of central China, constructing an evaluation system for the coordinated development of these two sectors. The coupling coordination degree is calculated using a combination weighting method and the coupling coordination degree model. Spatio-temporal evolution characteristics are analyzed through spatial autocorrelation, while the geographic detector explores the driving factors of spatial variation. The findings reveal a significant increase in coupling coordination between urbanization and tourism, transitioning towards a coordinated phase. Spatially, urbanization and tourism exhibit positive correlations, with high-value clusters in the southeast and northwest and low-value clusters in the south. The geographical detector identifies industrial factors as the most critical drivers of spatial variation. This study offers novel insights into the dynamics of urbanization and tourism, contributing to the broader literature by providing practical implications for regional planning and sustainable development. The results are relevant to the Wuling Mountain area and serve as a reference for similar regions globally. However, the study has certain limitations, such as regional specificity and data availability, which should be considered in the context of this research.

Keywords: urbanization; tourism industry; combination weighting method; coupling coordination degree model; spatio-temporal evolution; geographical detector

1. Introduction

The rural revitalization strategy, proposed by Chinese President Xi Jinping in 2017, is a new approach to promoting the development of China's rural areas. This strategy puts forward the requirements for modernizing China's rural areas and the integrated development of urban and rural areas. Tourism is a sustainable industry with low pollution, high profitability and fast development. The integration of tourism and urbanization is of great significance for the modernization of agriculture and rural areas and for promoting rural revitalization strategy in China (Zhao et al., 2015). This paper selected the Wuling Mountains, a pilot area for rural revitalization in China, as the research object. The Wuling Mountain area is characterized by its rich cultural heritage, diverse ecological environment, and significant economic potential, making it a critical region for studying the impacts of rural revitalization. This study aims to analyze the relevant data and propose policy recommendations for the coordinated development of urbanization and tourism in the Wuling Mountain area in Central China.

Regarding research methodology, the combination weighting method of relative entropy based on the entropy weight method and analytic hierarchy process was used to remove its singularity in the assignment method. Then, the coupling coordination degree model was combined with the TOPSIS method to quantitatively analyze the coupling coordination degree of urbanization and tourism. Then, the spatial autocorrelation analysis method is used to test the spatial differentiation of the coupling coordination degree of urbanization and tourism in the Wuling Mountain area. Finally, the geographic detector was used to investigate the single-factor and two-factor interactions of the driving factors affecting the degree of coupling coordination between urbanization and tourism and make an innovation in the study of two-factor interaction.

This paper attempts to introduce innovative research methods and make new contributions to elaborating theories and selecting countermeasures. Therefore, implementing the rural revitalization strategy in the Wuling Mountain area is very important in its application. It is also a guide and reference for developing urbanization and tourism in similar regions in other countries. Mullins coined the concept of tourism urbanization to illustrate the importance of coordinated development of urbanization and tourism in 1991. On this basis, scholars in China and abroad have studied the concepts, advantages and disadvantages, and types of urbanization and tourism (Allen et al., 1999; Williams et al., 1999; Zhu and Jia, 2006). Some scholars have also made a quantitative empirical analysis of urbanization and tourism's coupled and coordinated development. In the case of Yunnan Province, Peng et al. (2016) used the entropy weight method to empirically analyze the development level of urbanization and tourism. They then measured their coupling coordination degree (Peng et al., 2016). Zhao et al. (2020) used the entropy weight method and the coupling coordination degree model to measure tourism and new urbanization in 30 provinces in China from 2004 to 2014. Taking 14 prefecture-level cities in Gansu Province as the research object, Liu et al. predicted the coupling coordination degree of the efficiency of new urbanization, tourism, ecology and economy systems in Gansu Province from 2019 to 2025. They revealed its spatio-temporal evolution pattern (Liu et al., 2021). Weng et al. (2021) studied the spatiotemporal evolution and spatial differences of the coupling coordination among tourism, ecology, and urbanization in the Beijing-Tianjin-Hebei urban agglomeration. Weng et al. (2021) investigated the spatiotemporal evolution and spatial differences in the coupling coordination of tourism, ecology, and urbanization in the Beijing-Tianjin-Hebei region from 2007 to 2019. Their findings indicated growth trends across all three systems, transitioning from high coupling-low coordination to high coupling-high coordination.

Su et al. (2022) analyzed the coupling coordination between tourism development and urban residents' quality of life in Fujian Province, finding improvements in both systems from 2010 to 2019, with notable spatial variations. Chen (2023) studied the dynamic relationship between new urbanization and high-quality tourism development in six central Chinese provinces from 2001 to 2019, finding mutual influence and a cointegration relationship. Zhang et al. (2023) analyzed the coupling coordination between rural tourism and in-situ urbanization in Qinghai Province from 2010 to 2021. They observed upward trends and a diversified spatial development pattern. Wang et al. (2023) explored the spatiotemporal evolution and driving factors of the coupling coordination among tourism, ecological environment, and urbanization in Inner Mongolia from 2000 to 2019, revealing that central regions showed higher coordination compared to eastern and western regions. Li (2023) explored the coupling development mechanism of rural culture and tourism under the background of urbanization. Tian et al. (2023) studied the coupling coordination of tourism, urbanization, and ecological environment in Shandong, China, from 2001 to 2017. They found that tourism and urbanization levels increased steadily while the ecological environment fluctuated, with improved coordination in cities like Qingdao and Jinan.

Research on urbanization and tourism in China and internationally has focused on conceptual frameworks and measuring the degree of coupling coordination between these two systems. While many studies employ singular assignment methods to evaluate the coupling coordination degree, there has been limited exploration of the spatial heterogeneity inherent in these dynamics. Additionally, the quantitative analysis of how various driving factors influence the coupling coordination degree remains underdeveloped in the existing literature. This study addresses these gaps by introducing a more comprehensive methodological approach that incorporates spatial analysis and examines the interaction effects of multiple driving factors, thereby providing new insights into the complex relationship between urbanization and tourism.

2. Research methodology

This study aims to elucidate the spatio-temporal coupling coordination relationship between urbanization and tourism in the Wuling Mountain area in Central China and the driving factors that influence the coupling coordination degree. A comprehensive evaluation index system for urbanization and tourism development in the Wuling Mountain area was established, capturing the complex interactions between these two systems. The combination weighting method, which integrates the entropy weight method and the analytic hierarchy process (AHP), was utilized to derive weights for the evaluation indices to achieve this. The method addresses the limitations of using a single weighting approach by balancing subjective and objective factors, ensuring a more accurate assessment. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method was then applied to measure urbanization and tourism development levels. TOPSIS is chosen for its ability to effectively utilize the information contained in the original data, providing a robust reflection of differences among the evaluated options. Subsequently, the coupling coordination degree model was employed to quantitatively analyze the coordination degree between urbanization and tourism over time. This model measures the extent of coupling and captures the progression towards or away from coordination, offering insights into temporal dynamics.

Spatial autocorrelation analysis was conducted to investigate the spatial variation patterns of the coupling coordination degree. This method helps identify clustering patterns and spatial dependencies, revealing how coordination levels vary across the study area. Additionally, the geographic detector explored the driving factors behind these spatial variations, focusing on both single-factor effects and the interactions between factors. This approach is particularly innovative as it allows for the identification of nonlinear enhancement and bi-factor enhancement effects, providing a deeper understanding of the forces shaping the coupling coordination degree.

The study operates under the assumption that the selected indicators and methods adequately capture the dynamics between urbanization and tourism. However, it acknowledges certain limitations, such as the potential biases introduced by data availability and regional specificity. Data were sourced from official statistical yearbooks and online databases, which, while reliable, may not fully encompass all relevant aspects. Future studies should incorporate field surveys and additional qualitative data to further validate and expand upon these findings.

2.1. Index system building and data sources

Based on the mechanism of coordinated development of tourism and urbanization, this paper synthesizes the studies of scholars in China and abroad (Tang et al., 2017; Wang et al., 2020; Zhang, 2014). The years 2016 through 2019 were selected as the time points for the study, and the counties in the Wuling Mountain area were investigated. Due to some counties' severe lack of data, they were not included in the study area. Finally, the 41 counties (cities) in the Wuling Mountain area were determined as the study area. At the same time, an index system was constructed, as shown in **Table 1**, taking into account the actual situation of the Wuling Mountain area and the scientificity, rationality, and accessibility. The urbanization system (A1) included three primary indices: population urbanization (B1), social urbanization (B2) and economic urbanization (B3). The tourism system included two primary indices: tourism development level (B4) and tourism resource base (B5). Based on the primary indices, 12 secondary indices were determined to evaluate the level of tourism and urbanization development in the counties of the Wuling Mountain area.

Table 1. Index system of tourism and urbanization systems.

System	Primary index	Secondary index	Unit	Nature
Urbanization A1	Population urbanization B1	Percentage of urban population C1	%	+
		Number of employees in the secondary industry C2	Person	+
		Number of employees in the tertiary industry C3	Person	+
	Social urbanization B2	Number of beds in medical institutions C4	Bed	+
		Number of current students in regular secondary schools C5	Person	+
	Economic urbanization B3	GDP per capita C6	Yuan	+
		Total retail sales of consumer goods C7	10,000 yuan	+
		Percentage of the output value of the secondary industry to GDP C8	%	+
		Percentage of the output value of the tertiary industry to GDP C9	%	+
Tourism A2	Tourism development level B4	Total tourist revenue C10	100 million yuan	+
		Total tourist arrivals C11	10,000	+
	Tourism resource base B5	Number of intangible cultural heritage items in China C12	Item	+

The data on the number of employees in the secondary industry C2, the number of employees in the tertiary industry C3, the number of beds in medical institutions C4, and the number of current students in regular secondary schools C5 were selected from the Chinese County Statistical Yearbook. The data of the percentage of urban population C1, GDP per capita C6, total retail sales of consumer goods C7, the percentage of the output value of the secondary industry to GDP C8, the percentage of the output value of the tertiary industry to GDP C9, total tourist revenue C10, total tourist arrivals C11 were obtained from the Statistical Yearbook of Hunan Province, China, Statistical Yearbook of Guizhou Province, China, Statistical Yearbook of Chongqing City, China, Statistical Yearbook of Hubei Province, China, and statistical bulletins of counties in China. The number of intangible cultural heritage items in China C12 was obtained from the China Intangible Cultural Heritage website (http://www.ihchina.cn). Some of the data were supplemented by information published on the official websites of various departments, and individual data that were not available were inserted by interpolation.

2.2. Entropy weight method

The entropy weight method is a typical objective weighting method, and the concept of entropy is derived from thermodynamics. Information theory is used to measure the degree of disorder of a system, and the corresponding weight is determined by the amount of information provided by each index. The more significant the difference between the values of an index of the evaluation system, the smaller the entropy value, and the greater the weight of the corresponding weight. The entropy weight method determines the weights according to the degree of difference between indices. It can effectively correct the uncertainty of the weights caused by the subjective weighting method. The process of assigning weights by the entropy weight method is as follows (Tian and Zhou, 2021; Wei and Li, 2018):

1) The raw data were normalized. The original data matrix $X = (x_{ij})_{m\times n}$ was constructed with n being the number of indices and m being the number of samples. The matrix was standardized by using the range method to derive the new matrix $Y = (y_{ij})_{m\times n}$, where:

$$y_{ij} = \begin{cases} \dfrac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}}, \text{when the index is positive} \\ \dfrac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}}, \text{when the index is negative} \end{cases} \tag{1}$$

2) The information entropy e_j of the jth index is:

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij} \tag{2}$$

where: $k = \frac{1}{\ln m}, p_{ij} = \frac{y_{ij}}{\sum_{i=1}^{m} y_{ij}}$ (to avoid the meaningless $\ln p_{ij}$ when y_{ij}=0, y_{ij} is translated to the right by 10^{-11} unit).

3) The entropy weight w_j of the jth index is determined as:

$$w_j = \frac{1 - e_j}{\sum_{i=1}^{n}(1 - e_j)} \tag{3}$$

2.3. Analytic hierarchy process

The analytic hierarchy process is a typical subjective weighting method, which determines the weight of each index of the research object according to its importance based on expert experience. The technique is described as follows (Chen, 1997):

1) Build a hierarchical model. The influencing factors of the research object are stratified into the top, middle and bottom levels, and a multi-level structure is constructed.
2) Construct the judgment matrix. To determine the influence of each factor $X = \{x_1, x_2, \cdots, x_n\}$ on the target Z, a two-by-two comparison is used to express the ratio of the factors x_i and x_j on the target Z with a_{ij}. The relative importance of the factors, i.e., a_{ij}, is assigned by the 1–9 scale method (see **Table 1**), and the judgment matrix A is obtained. For example, when comparing two factors, if factor A is more important than factor B, you can assign a value of 5 to A and 1 to B. Through this comparative assignment method, the importance of different factors can be quantified, thereby establishing the judgment matrix.

$$A = (a_{ij})_{(m \times n)} \tag{4}$$

where, $a_{ij} > 0, a_{ij} = \frac{1}{a_{ji}}(i \neq j), a_{ij} = 1(i = j)$

3) Calculate the weights of factors in the judgment matrix. The weights of the structural layers are calculated using the power method to derive the eigenvector W and the eigenvalue $\lambda_{max}$of the judgment matrix A. The power method is a stepwise iterative calculation method calculated according to a specified accuracy. The principle of the method is as follows:
   i Take any initial positive vector $X^{(0)} = (x_1{}^{(0)}, x_2{}^{(0)}, \cdots, x_n{}^{(0)})^T$, and calculate as follows:

$$m_0 = \|X^{(0)}\|_\infty = \max\{x_i{}^{(0)}\} \text{ and } Y^{(0)} = \frac{X^{(0)}}{m_0} \tag{5}$$

   ii Compute iteratively. When $k = 0, 1, 2, \cdots n$, calculate as follows:

$$X^{(k+1)} = AY^{(k)}, m_{k+1} = \|X^{(k+1)}\|_\infty = \max\{x_i{}^{(k+1)}\}, Y^{(k+1)} = \frac{X^{(k+1)}}{m_{k+1}} \tag{6}$$

   iii Check for accuracy. When $|m_{k+1} - m_k| < \varepsilon$, move to Step 4); or let $k = k + 1$, move to step 2).
   iv Derive the maximum eigenvalue $\lambda_{\max}$ and its corresponding eigenvector. Normalize $Y^{(K+1)}$ and derive as follows:

$$W = \frac{Y_{k+1}}{\sum_{i=1}^{m} y_i{}^{(k+1)}}, \lambda_{\max} = m_{k+1} \tag{7}$$

4) Test the consistency. Calculate the consistency index CI:

$$\mathrm{CI} = \lambda_{\max}/(n-1) \tag{8}$$

when CI is equal to 0, A has a perfect consistency, and the larger the value of CI, the worse the consistency of A. To accurately measure the consistency of A, the average consistency index RI will be introduced so that the consistency ratio CR is:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{9}$$

When the CR is less than 0.10, A passes the consistency test; otherwise, A should be adjusted until the RI value of the judgment matrix when the CR is less than 0.1 is shown in **Table 2** below:

Table 2. Random index RI value.

Order *n*	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

2.4. Combination weighting method of relative entropy

The subjective weighting method effectively captures experts' preferences, while the objective weighting method reflects the data information. Combining these methods can mitigate human bias and fully represent the data, ensuring the scientific validity and objectivity of the evaluation. By integrating subjective judgments with objective measures, this approach offers a more balanced and comprehensive assessment. We adopted a combination weighting method based on relative entropy that integrates the subjective and objective weighting methods to compensate for the individual methods' shortcomings. The steps are as follows (Zhou and Wei, 2006):

1) Select P methods to assign weights and derive the weight vector u_k:

$$u_k = (u_{k1}, u_{k2}, \cdots, u_{km}) \tag{10}$$

where, $k = 1, 2, \cdots, p$.

2) Use the relative entropy o $h(u_i, u_j)$ f any two weight vectors $u_i, u_j (i, j = 1, 2, \cdots, p)$ to measure the degree of conformity of the two weight vectors:

$$h(u_i, u_j) = \sum_{l=1}^{m} u_{il} \, log \frac{u_{il}}{u_{jl}} u_k = (u_{k1}, u_{k2}, \cdots, u_{km}) \tag{11}$$

3) Based on the above principle, the combined weight $d = (d_1, d_2, \cdots, d_m)$will be derived, and the problem will be transformed into a mathematical programming problem:

$$\begin{cases} \min H(d) = \sum_{j=1}^{p} \sum_{i=1}^{m} d_i \log \frac{d_i}{u_{ji}} \\ s.t. \sum_{i=1}^{m} d_i = 1, d_i > 0 (i \in M) \end{cases} \tag{12}$$

4) The above optimization model has a globally optimal solution $d^* = (d_1^*, d_2^*, \cdots, d_m^*)$, where:

$$d_i^* = \frac{\prod_{j=1}^{p} (u_{ji})^{\frac{1}{p}}}{\sum_{i=1}^{m} \prod_{j=1}^{p} (u_{ji})^{\frac{1}{p}}} \tag{13}$$

where, $i = 1, 2, \cdots, m$.

5) Calculate the closeness $h(u_i, d^*)$ of each assignment result in the combined weight $d^* = (d_1^*, d_2^*, \cdots, d_m^*)$, where, $(i = 1, 2, \cdots, p)$.

6) Calculate the reliability of the assignment results. The greater the closeness, the greater the contribution in the combined weighting. Therefore, the reliability of weight a_i is as follows:

$$a_i = \frac{h(u_i, d^*)}{\sum_{i=1}^{p} h(u_i, d^*)} \tag{14}$$

where, $i = 1, 2, \cdots, p$.

7) Calculate the weight w_j:

$$w_j = \sum_{i=1}^{p} a_i u_{ij} \tag{15}$$

where, $i = 1, 2, \cdots, m$.

2.5. TOPSIS evaluation

1) Build a weighted evaluation matrix R from the dimensionless matrixY_{ij} obtained by the above range method and the weight matrix W_j obtained by the combination weighting method of relative entropy (Yu and Fu, 2004).

$$R = (r_{ij})_{n\times m} \tag{16}$$

where, $r_{ij} = W_j \times Y_{ij}$

2) Determine the optimal plan Q_j^+ and the worst plan Q_j^- based on the above weighting matrix *R*:

$$Q_j^+ = (\max r_{i1}, \max r_{i2}, \cdots, \max r_{im}) \text{ and } Q_j^- = (\min r_{i1}, \min r_{i2}, \cdots, \min r_{im}) \tag{17}$$

3) Calculate the Euclidean distances, d_i^+ and d_i^-, of each measurement plan from the optimal plan $Q_j^+$and the worst plan Q_j^-:

$$d_i^+ = \sqrt{\sum_{j=1}^{m}(Q_j^+ - r_{ij})^2} \text{ and } d_i^- = \sqrt{\sum_{j=1}^{m}(Q_j^- - r_{ij})^2} \tag{18}$$

4) Calculate the relative closeness $C_i$of each measurement plan to the ideal plan:

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{19}$$

C_i denotes the development level of the evaluated factor; the greater the value of C_i, the higher the development level. Consequently, the larger the C_i value, the better the object performs comprehensively on these indicators, and the lower the C_i value, the lower the development level.

2.6. Evaluation model of coupling coordination degree

The concept of coupling degree in physics is introduced to represent the phenomenon of two or more systems influencing each other through interaction, which is the coupling degree model (Wang et al., 2015). Since this paper investigates tourism and urbanization systems, i.e., the coupling degree *C*:

$$C = \left\{\frac{f(U)g(E)}{\left\{\frac{f(U)+g(E)}{2}\right\}^2}\right\}^{\frac{1}{2}} \tag{20}$$

Further, a coupling coordination degree model of tourism and urbanization was constructed as follows:

$$T = \alpha f(U) + \beta g(E) \text{ and } D = \sqrt{C \times T} \tag{21}$$

where *f*(*U*) denotes the score of the urbanization system; *g*(*E*) denotes the score of the tourism system; *C* denotes the coupling degree of tourism and urbanization; *D* denotes the coupling coordination degree of tourism and urbanization; *T* denotes the harmonic index of tourism and urbanization; and α and β denote the contributions of urbanization and tourism, respectively. According to the existing research results (Gao et al., 2013), it is conditioned that $\alpha = 0.6, \beta = 0.4$. Meanwhile, the coupling coordination degree of tourism and urbanization was divided into 10 levels, as shown in **Table 3** below, based on the classification of coordination degrees by scholars in China and abroad (Hong et al., 2024):

Table 3. Classification standard of coupling coordination degree.

No.	Coupling coordination degree interval	Coordination level
1	0–0.1	Extreme disorder
2	0.1001–0.2	Serious disorder
3	0.2001–0.3	Moderate disorder
4	0.3001–0.4	Light disorder
5	0.4001–0.5	Near disorder
6	0.5001–0.6	Poorly coordinated
7	0.6001–0.7	Primary coordination
8	0.7001–0.8	Medium coordination
9	0.8001–0.9	Good coordination
10	0.9001–1.0	High coordination

2.7. Spatial auto-correlation

Moran'I usually expresses spatial autocorrelation analysis, including global and local spatial autocorrelation (Wu et al., 2018). Moran's I is used to measure spatial autocorrelation, evaluating the average degree of association of spatial units with their surrounding areas across a region. It helps in understanding the spatial structure and patterns of geographical phenomena. The global Moran'I can analyze the spatial distribution of the coupling coordination degree between tourism and urbanization in the Wuling Mountain area and determine whether there is a clustering effect. The global Moran'I is calculated by the formula below:

$$I = \frac{n}{S_0} \times \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\sum_{i}^{n}(x_i - \overline{x})^2} \tag{22}$$

where n denotes the number of administrative counties studied, x_i and x_j denotes the observed values of the county-level administrative districts, $\overline{x}$ denotes the mean value of the observed values, W_{ij} denotes the spatial weight matrix and S_0 denotes the sum of the spatial weight matrices.

The local Moran'I can be used to determine where the clustering effect occurs by the Moran scatter plot and LISA cluster plot. It is calculated by the formula below:

$$I_i = \frac{x_i - \overline{x}}{m_0 \sum_{j=1}^{n}(x_j - \overline{x})} \tag{23}$$

where, x_i has the same meaning as $\overline{x}$ above, while m_0 denotes the regional area.

2.8. Geographical detector

The geographical detector is a statistical method proposed by Wang Jinfeng et al. in China to investigate the spatial variation and reveal the driving factors. The most distinctive feature of the geographical detector is that it can detect both the spatial variation of a single variable and the causality of the spatial distribution between two variables (Wang and Xu, 2017). The geographical detector comprises four detectors: factor, risk, interaction, and ecological. In this paper, factor and interaction detectors are used.

1) Factor detector: The purpose is to detect the extent to which an independent variable *X* explains the spatial variance of the dependent variable *Y*. the q-value measures the degree of explanation:

$$q = 1 - \frac{\sum_{d=1}^{L} N_d {\sigma_d}^2}{N\sigma^2} \quad (24)$$

where L is the layer of the coupling coordination degree *Y* or the influence factor *X*, i.e., classification or partitioning; N_d and *N* denotes the number of cells in layer *d* and the whole area, respectively; σ_d^2 and σ^2 denote the coupling coordination degree *Y* variance in layer d and the whole area, respectively. The range of values of q is $[0, 1]$. The larger the value of q, the stronger the ability of the influencing factor to explain the coupling coordination degree *Y*.

2) Interaction detector: The purpose is to detect whether the combined effect of the influencing factors X_1 and X_2 increases or decreases the explanatory power of the coupling coordination degree *Y*, or whether the effects of these influences on *Y* are independent. For its measurement, firstly, the q-values of the two independent variables on *Y* were calculated separately, i.e., $q(X_1)$ and $q(X_2)$. Secondly, the explanatory power $q(X_1 \cap X_2)$ of the interaction of the two independent variables on the dependent variable *Y* was calculated. Then, these results were compared, and finally, the relationship between the two influences was classified into 5 categories in **Table 4** below.

Table 4. Types of the interaction of two independent variables on the dependent variable.

Diagram	Criterion	Interaction
	$q(X_1 \cap X_2) < \mathrm{Min}(q(X_1), q(X_2))$	Nonlinear attenuation
	$\mathrm{Min}(q(X_1), q(X_2)) < q(X_1 \cap X_2) < \mathrm{Max}(q(X_1), q(X_2))$	Single-factor nonlinear attenuation
	$q(X_1 \cap X_2) > \mathrm{Max}(q(X_1), q(X_2))$	Bi-factor enhancement
	$q(X_1 \cap X_2) = q(X_1) + q(X_2)$	Independent
	$q(X_1 \cap X_2) > q(X_1) + q(X_2)$	Nonlinear enhancement

3. Empirical analysis

This paper analyzes the spatio-temporal evolution and driving factors of the degree of coupling coordination between urbanization and tourism based on the above research methods. Moreover, a quantitative analysis will be conducted on the spatio-temporal evolution pattern of the coupling coordination degree between urbanization and tourism in the Wuling Mountain area from 2016 to 2019, as well as its driving factors. Thus, the complex coupling relationship between urbanization and tourism in the Wuling Mountain area can be identified.

3.1. Comprehensive evaluation of urbanization level and tourism development level

The combined weight values of the indices were determined based on the entropy weight method and analytic hierarchy process. The judgment matrix was determined using the analytic hierarchy process combined with the experience of relevant experts, and the weight values were calculated using yeah. The weights were calculated using the entropy weight method and the relative entropy of the combination weighting method with MATLAB. The specific weight values are shown in **Table 5** below:

Table 5. Weights of various indices.

System	Secondary index	Weight by entropy weight method	Weight by analytic hierarchy process	Weight by combination weighting method of relative entropy
Urbanization	C1	0.0324	0.1856	0.1154
	C2	0.1715	0.0405	0.1005
	C3	0.0853	0.0708	0.0774
	C4	0.1775	0.0409	0.1035
	C5	0.1299	0.1226	0.1259
	C6	0.0481	0.2168	0.1395
	C7	0.1925	0.1819	0.1868
	C8	0.1146	0.0525	0.0810
	C9	0.0482	0.0885	0.0700
Tourism	C10	0.4106	0.5936	0.5015
	C11	0.3428	0.2493	0.2964
	C12	0.2466	0.1571	0.2022

From the weight values using the combination weighting method of relative entropy in **Table 5** above, it can be seen that total retail sales of consumer goods (0.1868) had the largest share in the comprehensive index system of urbanization. Therefore, total retail sales of consumer goods are an essential factor influencing the urbanization progress of the Wuling Mountain area. Total tourist revenue (0.5015) had the largest share in the comprehensive index system of tourism, so increased total tourist revenue is a powerful measure to enhance the comprehensive level of tourism.

The TOPSIS method was comprehensively used to evaluate 41 counties in the Wuling Mountain area. The relative ranking was obtained by adding up the comprehensive scores of each county from 2017 to 2019. The specific results of the urbanization development level are shown in **Table 6**.

As shown in **Table 6**, compared with 2016 before the rural revitalization strategy, the urbanization development level of counties in the Wuling Mountain area tended to increase after implementing the rural revitalization strategy. It shows that implementing the rural revitalization strategy in China has contributed significantly to urbanization in the Wuling Mountain area. Enshi County, Lianyuan City, and Xinhua County ranked among the 42 counties in the Wuling Mountain area regarding urbanization development level. These counties were relatively well developed because their higher-weight index values were better developed. Finally, the urbanization development level of the Wuling Mountain area differed sharply among counties, indicating uneven regional development.

Table 6. TOPSIS evaluation results of urbanization development level in 2016–2019.

	2016	**2017**	**2018**	**2019**	**Relative ranking**
Longshan County	0.2442	0.2674	0.2832	0.2822	29
Baojing County	0.1906	0.1990	0.2117	0.2322	38
Huayuan County	0.2372	0.2614	0.2561	0.2557	32
Fenghuang County	0.2729	0.2838	0.2942	0.2819	22
Mayang County	0.2111	0.2196	0.2334	0.2370	37
Sangzhi County	0.2602	0.2806	0.2917	0.2887	25
Yongshun County	0.2211	0.2360	0.2491	0.2562	35
Guzhang County	0.1740	0.1773	0.1927	0.2010	40
Luxi County	0.2269	0.2324	0.2329	0.4184	26
Yuanling County	0.3350	0.3581	0.3426	0.3238	16
Jingzhou County	0.2640	0.2814	0.3007	0.2866	23
Tongdao County	0.1668	0.1869	0.2023	0.2257	39
Anhua County	0.3649	0.4102	0.4200	0.3966	8
Xinhua County	0.4183	0.4538	0.4768	0.5525	3
Longhui County	0.3690	0.4115	0.4320	0.4325	6
Dongkou County	0.3628	0.3958	0.4108	0.4287	7
Suining County	0.2288	0.2358	0.2501	0.2523	34
Lianyuan City	0.4565	0.4762	0.4917	0.4896	2
Xinshao County	0.3564	0.3592	0.3782	0.3810	13
Shaoyang County	0.3381	0.3541	0.3841	0.4178	12
Wugang City	0.3646	0.3939	0.3893	0.4162	10
Xinning County	0.2782	0.3006	0.3190	0.3382	18
Chengbu County	0.1614	0.1756	0.1885	0.2063	41
Changyang County	0.2379	0.2496	0.3081	0.3355	24
Badong county	0.2867	0.2589	0.3225	0.3435	20
Jianshixian	0.2654	0.2476	0.3195	0.3455	21
Enshi County	0.5242	0.5044	0.5913	0.6607	1
Hefeng County	0.2244	0.2225	0.2480	0.2629	36
Lichuan County	0.4145	0.3546	0.4561	0.5066	5
Xianfeng County	0.2907	0.3659	0.3030	0.3361	17
Laifeng County	0.2551	0.2482	0.2607	0.3160	28
Shizhu County	0.3244	0.3857	0.3728	0.3919	14
Fengdu County	0.3852	0.4273	0.3944	0.5760	4
Wulong County	0.3427	0.3695	0.3832	0.4838	9
Pengshui County	0.3029	0.3230	0.3565	0.4367	15
Youyang County	0.3460	0.2996	0.4326	0.4193	11
Wuchuan County	0.2534	0.2410	0.2697	0.2815	30
Yanhe County	0.2376	0.2443	0.2707	0.2892	31
Dejiang County	0.3033	0.3030	0.3099	0.3155	19
Shiqian County	0.1965	0.2321	0.2580	0.2845	33
Songtao County	0.2811	0.2492	0.2497	0.3026	27

Their tourism development levels are shown in **Table 7** below:

Table 7. TOPSIS evaluation results of tourism development level in 2016–2019.

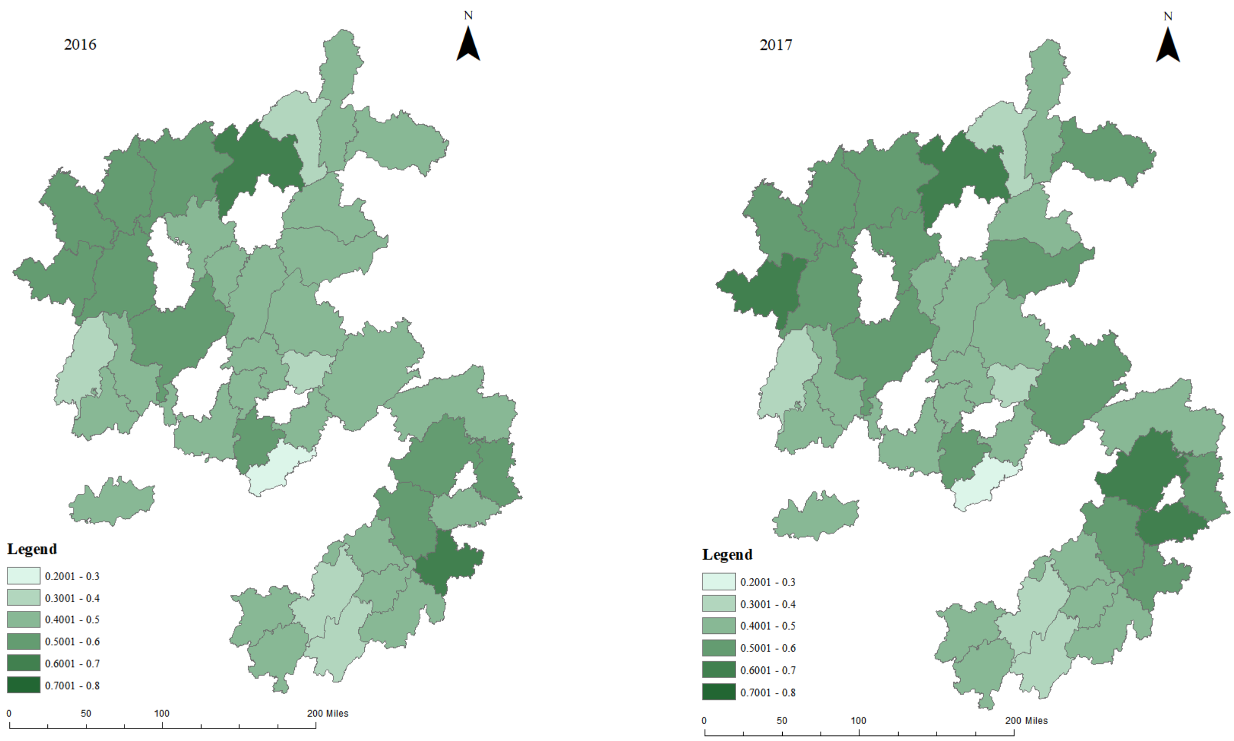
	2016	2017	2018	2019	Relative ranking
Longshan County	0.1555	0.1584	0.1626	0.1935	24
Baojing County	0.1479	0.1486	0.1549	0.1570	28
Huayuan County	0.2115	0.2129	0.2155	0.2226	20
Fenghuang County	0.3863	0.4308	0.4848	0.5382	1
Mayang County	0.0091	0.0103	0.0114	0.0134	41
Sangzhi County	0.2235	0.2284	0.2346	0.2219	16
Yongshun County	0.2281	0.2319	0.2541	0.2800	13
Guzhang County	0.0828	0.0852	0.1162	0.1162	33
Luxi County	0.2605	0.2614	0.2697	0.2709	10
Yuanling County	0.1583	0.1626	0.1776	0.1926	23
Jingzhou County	0.0823	0.0829	0.0835	0.0910	38
Tongdao County	0.2188	0.2266	0.2321	0.2275	17
Anhua County	0.0858	0.1153	0.1505	0.1843	32
Xinhua County	0.2869	0.3145	0.3525	0.3831	5
Longhui County	0.2623	0.2638	0.2652	0.2654	11
Dongkou County	0.0819	0.0861	0.1026	0.0823	36
Suining County	0.0821	0.0912	0.0987	0.0954	34
Lianyuan City	0.1768	0.2051	0.1293	0.1558	25
Xinshao County	0.0945	0.6022	0.0881	0.0848	19
Shaoyang County	0.4635	0.1644	0.1663	0.1975	14
Wugang City	0.0804	0.0819	0.0875	0.1037	35
Xinning County	0.1476	0.1585	0.1762	0.1843	26
Chengbu County	0.0790	0.0869	0.0899	0.0930	37
Changyang County	0.2563	0.2799	0.3055	0.3329	7
Badong county	0.1929	0.2059	0.2272	0.2539	18
Jianshixian	0.0437	0.0532	0.0733	0.0897	39
Enshi County	0.3620	0.2964	0.4909	0.5377	2
Hefeng County	0.1487	0.1507	0.1515	0.1536	29
Lichuan County	0.2279	0.2534	0.2932	0.3436	9
Xianfeng County	0.1854	0.1971	0.2008	0.1800	22
Laifeng County	0.2107	0.2145	0.2160	0.2176	21
Shizhu County	0.2398	0.2580	0.2832	0.3401	8
Fengdu County	0.1869	0.2250	0.2689	0.2395	15
Wulong County	0.3169	0.3562	0.4512	0.4936	3
Pengshui County	0.2978	0.3455	0.4006	0.4788	4
Youyang County	0.2649	0.2851	0.3088	0.3433	6
Wuchuan County	0.0262	0.0412	0.0594	0.0792	40
Yanhe County	0.1132	0.1421	0.1766	0.2039	27
Dejiang County	0.0847	0.0916	0.1579	0.2051	31
Shiqian County	0.2308	0.2514	0.2682	0.2987	12
Songtao County	0.0885	0.1345	0.1673	0.1889	30

From **Table 7** above, it can be seen that tourism in the Wuling Mountain area showed an overall upward trend from 2016 to 2019. Fenghuang County, Enshi County and Wulong County have established the primary conditions for tourism development due to their rich tourism resources. Secondly, since the urbanization level of these areas is also relatively well developed, which has laid some material foundation for tourism development, they were among the top in the comprehensive evaluation of tourism. Compared with the comprehensive evaluation of the urbanization development level, the difference between counties is less volatile in the overall evaluation of the tourism development level.

3.2. Analysis of the spatio-temporal evolution of the coupling coordination degree between urbanization and tourism

3.2.1. Analysis of spatial distribution characteristics and evolutionary trends

Based on the values of urbanization and tourism calculated by TOPSIS, the coupling coordination degree of the two systems in the Wuling Mountain area from 2016 to 2019 was calculated. To visualize the changes in the coupling coordination degree of the Wuling Mountain area, the spatial distribution graph was plotted with the help of ArcGIS to show the coupling coordination degree of urbanization and tourism in the Wuling Mountain area (**Figure 1**). The degree of coupling coordination of urbanization and tourism in the Wuling Mountain area steadily increased. And some counties have significantly changed from disorder to coordination, mainly in Luxi County from 2016 (0.49) to 2019 (0.59); Anhua County from 2016 (0.44) to 2019 (0.54); and Yanhe County from 2016 (0.42) to 2019 (0.50). Secondly, some counties already in the coordination stage in 2016 tended to get more coordinated, mainly in some counties in the northwest and southeast regions, and the scope is expanding.



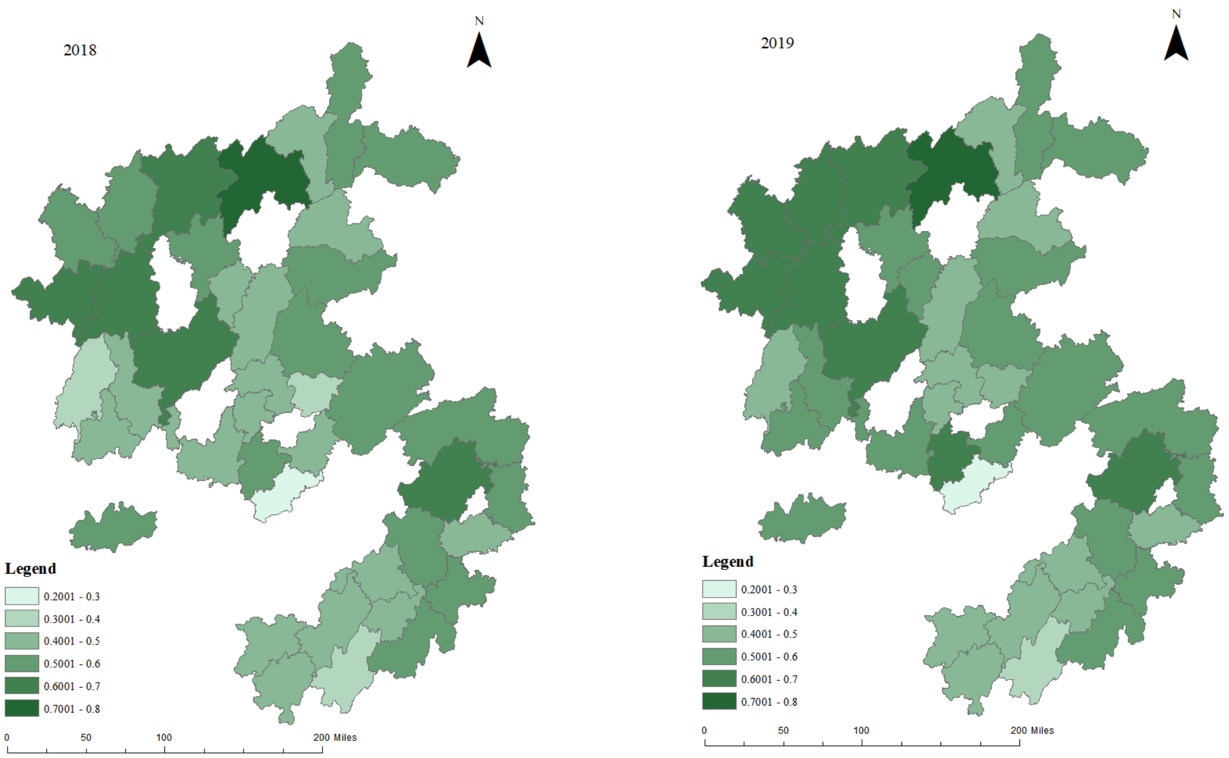


Figure 1. Spatial distribution of coupling coordination degree between urbanization and tourism in the Wuling Mountain area from 2016 to 2019.

The trend analysis tool in ArcGIS was used to explore further the spatial distribution characteristics of the coupling coordination degree between urbanization and tourism in the Wuling Mountain area. The attribute value *Z* denotes the coupling coordination degree of the 41 counties in the Wuling Mountain area. A 3D trend chart was plotted, where the positive *X*-axis represents due east, the positive *Y*-axis represents due north, and the *Z*-axis represents the vertical direction (**Figure 2**). Therefore, the spatial distribution of the coupling coordination degree of the Wuling Mountain area is visualized in the model. From the spatial projection of **Figure 2**, the east-west direction presented a concave *U*-shaped pattern. From west to east, it showed that the coupling coordination degree of the counties in the Wuling Mountain area decreased first and then increased, with a high degree at both ends and a low degree in the middle in the east-west direction. The north-south direction showed an increasing trend from south to north, which confirmed the significant difference between counties in the northward direction. Moreover, it further indicated the significant spatial variation in the degree of coupling coordination between urbanization and tourism in the Wuling Mountain area.

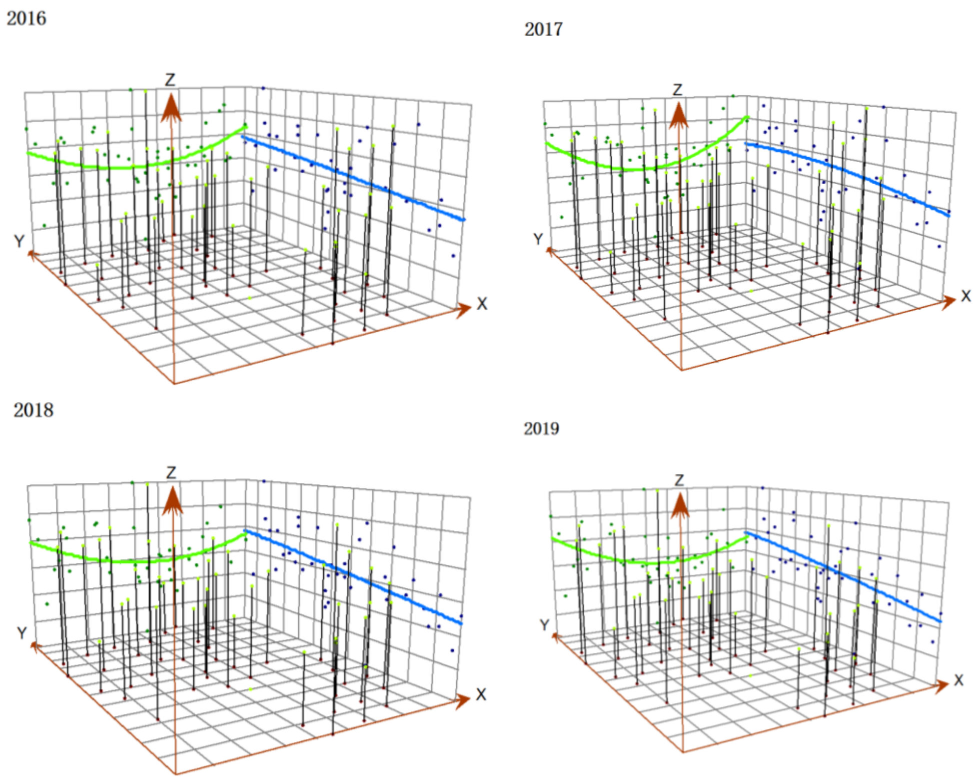


Figure 2. Change trend of the spatial pattern of coupling coordination degree between urbanization and tourism in the Wuling Mountain area from 2016 to 2019.

3.2.2. Spatial autocorrelation analysis

A global Moran'I statistical test was conducted on the coupling coordination degree of urbanization and tourism in 41 counties of the Wuling Mountain area using GeoDA. In 2017, the first year after implementing rural revitalization, the global Moran'I was 0.274, where $Z = 2.5794$, when permutation was 999, which was more significant than 1.96 and passed the significance test at a 5% confidence level. The global Moran'I in 2016, 2018 and 2019 were 0.105, 0.138 and 0.168, respectively, and all passed the significance test at the 10% confidence level. The results demonstrated a positive spatial correlation in the coupling coordination degree of urbanization and tourism in the Wuling Mountain area, which is not entirely randomly distributed. Moreover, the coupling coordination degree has a specific clustering effect in the neighboring areas. Precisely, areas with low coupling coordination degrees lie close to each other. At the same time, areas with high coupling coordination degrees also lie close to each other, and the growth of coupling coordination degrees also showed some convergence. Moran'I values were mainly distributed between 0.1 and 0.3, and its positive correlation was weak because of the poor economic foundations of the Wuling Mountain area, resulting in the low level of infrastructure construction and, thus, the weak development trend of inter-regional coordination.

The Moran scatter plot and LISA cluster plot were drawn for 2017 with a large Moran'I and significant clustering effect. Local autocorrelation analysis was conducted for the counties in the Wuling Mountain area. Thus, it facilitates the analysis of the spatial distribution of the coupling coordination degree of the counties and the surrounding counties, and the results are shown in **Figure 3**.

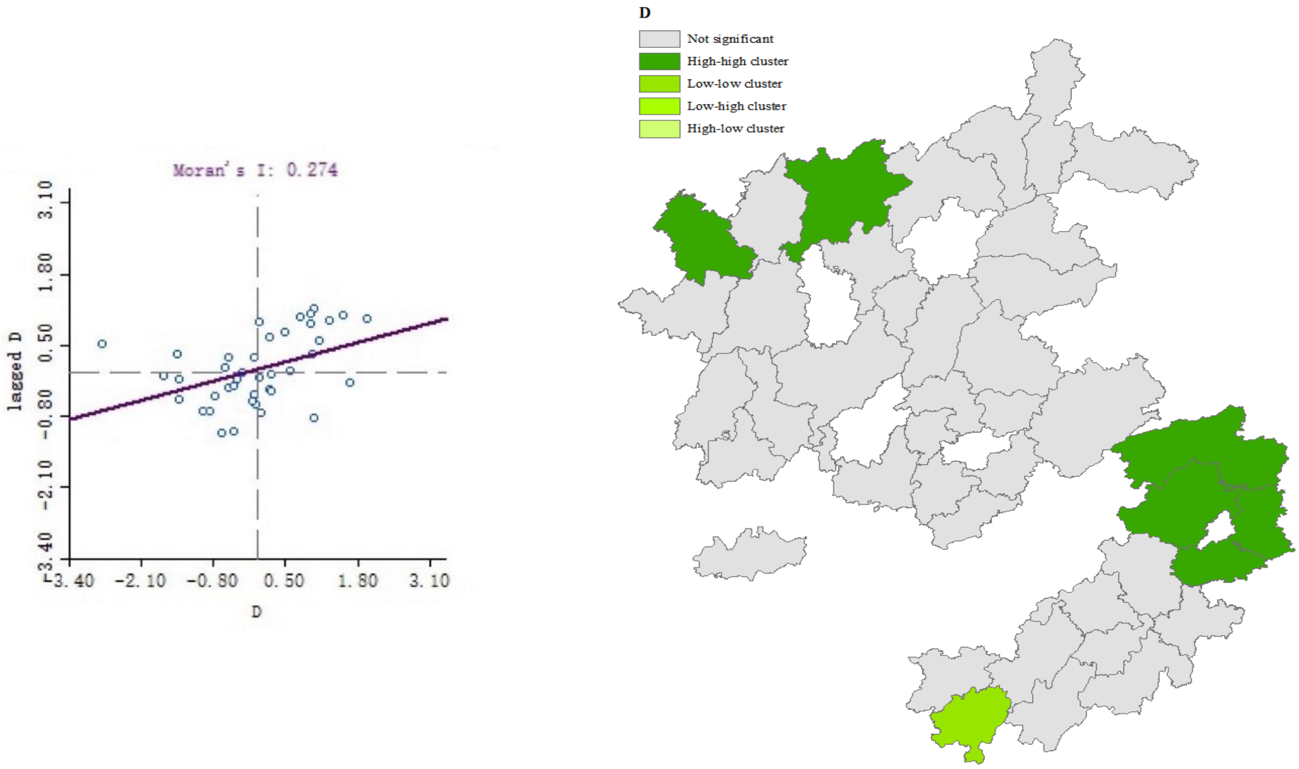


Figure 3. Moran scatter plot and LISA cluster plot of coupling coordination degree in 2017.

Figure 3 shows that the 41 counties in the Wuling Mountain area were mainly distributed in the first and third quadrants, i.e., the high and low values cluster. Therefore, the coupling coordination degree of the Wuling Mountain area had a positive spatial correlation in 2017. From the Moran scatter plot and the LISA cluster plot in **Figure 3**, we can see that there were 6 counties in the first quadrant, accounting for 14.63% of the total, and these counties were mainly located in the northwest and southeast of the Wuling Mountain area. One county was located in the third quadrant, accounting for 2.44% of the total, mainly in the southern region. Therefore, some counties in the Wuling Mountain area are well coordinated in urbanization and tourism, have a high coupling coordination degree, and can boost the development of the surrounding counties to some extent. These counties mainly include Fengdu County and Lichuan City in the northwest and Anhua County, Xinhua County, Lianyuan City and Xinshao County in the southeast. The areas with poor coordination degree of urbanization and tourism and low coupling coordination degree of surrounding counties and cities are concentrated in the vicinity of Tongdao County.

3.3. Analysis of driving factors

3.3.1. Selection of driving factors

The degree of coupling coordination between urbanization and tourism is influenced by economic, policy, cultural, educational, resource, and regional factors, and there may be a common influence among them. In light of the research results of Chinese scholars and the actual situation of the Wuling Mountain area (Tang et al., 2021; Xiao et al., 2022), industrial driving factors, resource driving factors, economic driving factors, and educational driving factors were selected. The geographical detector was used to analyze the driving factors for the degree of coupling coordination between urbanization and tourism in the Wuling Mountain area. The number of employees in the tertiary industry, total tourist revenue and tourist arrivals represent industrial driving factors. The number of intangible cultural heritage items in China represents resource-driving factors. Economic driving factors are represented by total retail sales of consumer goods and GDP per capita. The number of current students in regular secondary schools represents educational driving factors.

The geographical detector can only recognize type-valued variables. Therefore, before running the geographic detector, all continuous variables were converted into type-valued variables using the natural breaks, quantile, and equal interval methods in ArcGIS 10.8. The degree of coupling coordination between urbanization and tourism in the Wuling Mountain area was selected as the dependent variable, and the rest were independent variables. The specific classification methods are shown in **Table 8** below:

Table 8. Classification of driving factors for coupling coordination degree.

Driving factor	Detected index	Index code	Classification method
	the coupling coordination degree between urbanization and tourism	Y	Equal interval method
Resource driving factors	Number of intangible cultural heritage items in China	X1	Equal interval method
Industrial driving factors	Total tourist revenue	X2	Natural breaks method
	Total tourist arrivals	X3	Natural breaks method
	Number of employees in the tertiary industry	X6	Natural breaks method
Economic driving factors	GDP per capita	X7	Quantile method
	Total retail sales of consumer goods	X5	Quantile method
Educational driving factors	Number of current students in regular secondary schools	X4	Quantile method

3.3.2. Analysis of influencing factors

The driving factors were classified according to the above method. The study area was divided into a 10 km × 10 km grid in ArcGIS and then extracted. Then, the geographic detector model was used to explore the ability of each factor to explain the spatial variation of the degree of coupling coordination between urbanization and tourism in the Wuling Mountain area. Finally, the factor detector in the geographic detector was used to derive the q-value of the explanatory power of different driving factors on the spatial variation of the coupling coordination degree between urbanization and tourism in the Wuling Mountain area. The explanatory power of the individual factors is shown in **Table 9** below (all factors passed the 5% significance test):

From **Table 9**, the q-values of various driving factors differed in different years, with some time heterogeneity. In terms of the q-values of the explanatory power, total tourist revenue, total tourist arrivals, total retail sales of consumer goods, and the number of current students in regular secondary schools were the significant factors affecting the coupling coordination degree between urbanization and tourism in the Wuling Mountain area. Among them, the explanatory power of total tourist revenue tended to grow continuously from 0.57 in 2016 to 0.8 in 2019. It shows that total tourist revenue plays an increasingly substantial role in driving the coupling coordination degree of the Wuling Mountain area, which is the most critical factor in enhancing the integration of urbanization and tourism. The other driving factors showed fluctuations in different years, but the fluctuations were insignificant and tended to be generally stable.

Table 9. Detection of coupling coordination degree driving factors in 2016–2019.

Driving factor	Detected index	Index code	2016	2017	2018	2019
Resource driving factors	Number of intangible cultural heritage items in China	X1	0.15	0.11	0.14	0.08
Industrial driving factors	Total tourist revenue	X2	0.57	0.56	0.65	0.80
	Total tourist arrivals	X3	0.56	0.56	0.64	0.63
	Number of employees in the tertiary industry	X6	0.24	0.20	0.30	0.29
Economic driving factors	GDP per capita	X7	0.19	0.20	0.12	0.31
	Total retail sales of consumer goods	X5	0.32	0.35	0.37	0.30
Educational driving factors	Number of current students in regular secondary schools	X4	0.38	0.23	0.32	0.30

Among all driving factors, industrial driving factors are the most powerful, followed by economic, educational, and resource-driving factors. The industrial driving factors significantly contribute to coordinating urbanization and tourism development in the Wuling Mountain area. It is crucial to revitalize the industry through a rural revitalization strategy. As the foundation of the rural revitalization strategy, economic driving factors are also indispensable. Education is a solid backbone as the foundation for strengthening the nation. Resource-driving factors play a less important role than the other three driving factors but also affect the coordinated development of urbanization and tourism.

Economic driving factors are the underlying conditions that promote their coordinated development. Educational driving factors are the fundamental approach to the increased coordination degree. Resource-driving factors can also help improve the degree of coupling coordination. Industrial driving factors can significantly enhance the Wuling Mountain area's coordinated urbanization and tourism development.

The interaction detector in the geographic detector was used to investigate the common influence of two factors on the degree of coupling coordination between urbanization and tourism in the Wuling Mountain area and analyze their interaction. To ensure that the conclusions drawn are close to the present status, the data from 2019 were intercepted for detailed analysis. The results show that the interaction of any two factors on the coupling coordination degree between urbanization and tourism in the Wuling Mountain area was greater than that of a single factor. It was mainly manifested as bi-factor enhancement or nonlinear enhancement, with no mutually independent factors (as in **Table 10**). X2 ∩ X5 had the most significant explanatory power with a q-value of 0.96, which means that the interaction between total tourist revenue and total retail sales of consumer goods was the most powerful. It indicated that the interaction of total tourist revenue and total retail sales of consumer goods significantly affected the coupling between urbanization and tourism in the Wuling

Mountain area. X4 ∩ X7 had the least explanatory power, with a q value 0.30, and its driving effect was weak. It started earlier to improve the GDP per capita and the number of current students in regular secondary schools, and it has established some foundation. Therefore, it has less influence on the degree of coupling coordination of urbanization and tourism in the Wuling Mountain area at a later stage. Secondly, the interactions of X2 ∩ X6, X3 ∩ X6, X1 ∩ X2 and X2 ∩ X7 were also significant, with q-values reaching more than 90%, and were also important ways to drive the coordinated development of urbanization and tourism.

Table 10. Interaction detection of coupling coordination degree driving factors in 2019.

X	X1	X2	X3	X4	X5	X6
X2	NE (0.93)					
X3	NE (0.81)	BE (0.80)				
X4	NE (0.52)	BE (0.89)	BE (0.89)			
X5	NE (0.72)	BE (0.96)	BE (0.63)	NE (0.86)		
X6	NE (0.43)	BE (0.93)	BE (0.93)	BE (0.82)	NE (0.68)	
X7	NE (0.65)	BE (0.91)	BE (0.88)	NE (0.30)	NE (0.56)	NE (0.70)

Note: NE denotes nonlinear enhancement; BE denotes bi-factor enhancement.

4. Conclusions and recommendations

This paper analyzed the spatio-temporal distribution pattern of the coupling coordination degree between urbanization and tourism based on the panel data of 41 counties in the Wuling Mountain area from 2016 to 2019. Then, the weights of indices were calculated using the combination weighting method. The coupling coordination degree model and TOPSIS method were used to analyze the two systems' coordination degrees quantitatively. The coupling degree and evolution of urbanization and tourism in the Wuling Mountain area were investigated. It was done by using the spatial autocorrelation method. Then, the factors contributing to the spatial variation of the coupling coordination degree of urbanization and tourism in the Wuling Mountain area were analyzed using the geographic detector.

The results of the data analysis indicated that the overall level of urbanization and tourism in the Wuling Mountain area remained on the rise, and the degree of coupling coordination between them also continued to rise. Since implementing the rural revitalization strategy, all counties in the Wuling Mountain area have developed economies. The counties' economic development has propelled the urbanization of the counties, and the infrastructure of the counties has been upgraded, which has boosted the development of tourism. In turn, tourism development stimulates economic development. Therefore, urbanization and tourism are mutually coordinated and promoted. The level of urbanization and tourism in the Wuling Mountain area has been improved accordingly, and the degree of coupling coordination between them has been constantly enhanced.

The results of the data analysis also showed that the degree of coupling coordination between urbanization and tourism in the Wuling Mountain area had a positive correlation in space. In the east-west direction, it follows a U-shaped pattern, while in the north-south direction, it grows from south to north, and in the southeast and northwest directions, there is a cluster of high values, while in the south, there is a cluster of low values. The main reason is that the counties in the southeast and northwest have a stronger economic foundation than those in other regions. Therefore, these counties enjoy well-developed infrastructure, convenient transportation, and high living standards, which can drive the development of other surrounding counties. In contrast, the counties in the south are generally backward regarding the economic base, and their transportation is not as convenient as that of other counties. In addition, the Wuling Mountains area is predominantly mountainous, which leads to weak cooperation among the counties in the south and the emergence of a cluster of low values.

The results of the data analysis further revealed that the industrial driving factors are significant factors influencing the coupling coordination degree of urbanization and tourism in the Wuling Mountain area. Total tourist revenue and arrivals influence the coupling coordination degree significantly stronger than other factors. In contrast, the interaction of total tourist revenue and total retail sales of consumer goods influenced the degree of coupling coordination. When interacting with any two factors, the driving factors show nonlinear or bi-factor enhancement.

Based on the findings, we propose the following recommendations to enhance the coordinated development of urbanization and tourism in the Wuling Mountain area, informed by a detailed analysis of driving factors and spatial patterns under the rural revitalization strategy:

1) Targeted Infrastructure and Transportation Improvements: Investment should be strategically directed towards counties with lower coupling coordination degrees, prioritizing enhancing infrastructure and public transportation. This approach supports the overall goals of the rural revitalization strategy and addresses the specific needs identified in less developed areas. By learning from the best practices in the northwestern and southeastern counties, which exhibit higher coordination levels, these regions can implement comprehensive and scientifically grounded development plans tailored to their local conditions.
2) Fostering Regional Economic Integration: A linked development mechanism should be established to build a cohesive economic circle within the Wuling Mountain area. The focus should be on leveraging the solid economic foundations and high coupling coordination levels of northwestern and southeastern counties to drive growth across the entire region. This includes enhancing collaboration between counties, integrating local industries, and cultivating a skilled workforce. Additionally, leveraging natural tourism resources to develop derivative products and related service industries can stimulate economic activity and promote industrial innovation. These efforts are crucial for narrowing regional disparities and raising the overall development level across the Wuling Mountain area.
3) Enhancing Industrial and Economic Driver: The geographic detector analysis highlighted the critical role of industrial and economic driving factors in influencing the coupling coordination degree. Therefore, increasing investment in these areas is essential. Specifically, expanding urbanization and tourism-related infrastructure and services in critical industrial sectors can significantly

improve the coordination between urbanization and tourism. Strategic investments should focus on sectors that demonstrate the most substantial impact on coordination, as identified by the interaction effects in our analysis, to maximize the synergistic development of urbanization and tourism.

These recommendations, derived from a nuanced understanding of the spatial and temporal dynamics in the region, aim to provide a more tailored and practical framework for fostering sustainable development in the Wuling Mountain area. Future research should continue to refine these strategies by incorporating more comprehensive data and exploring additional driving factors that may influence the coordination between urbanization and tourism.

While this paper provides valuable insights for scholars studying the coupled and coordinated development of urbanization and tourism, it also has certain limitations. Firstly, the data used in this study were collected from relevant statistical yearbooks and publicly available sources on the Internet. The lack of field investigations may have led to gaps in data availability, and some quality indicators were excluded due to insufficient data, which could have affected the construction of the index system. Therefore, there is a need for a more comprehensive, accurate, and scientifically robust index system in future research. Secondly, this study primarily relies on historical data to forecast trends, which may require further analysis and validation. Thirdly, although many factors can influence the degree of coupling coordination between urbanization and tourism, this paper analyzes only four driving factors. Constructing a complete driving factor system remains a complex challenge, as research on these influencing factors is still relatively scarce. Future studies should address these issues by conducting extensive field surveys, incorporating a broader range of indicators, and utilizing advanced analytical techniques to enhance the understanding of these dynamics.

Future research should address data limitations by conducting extensive field surveys and developing a more comprehensive index system. Incorporating a wider range of social, economic, environmental, and policy factors will provide a more holistic understanding of the coupling between urbanization and tourism. Advanced modeling techniques like spatial econometrics and big data analytics can uncover complex relationships and enhance spatial analysis. Comparative studies across diverse regions will also help validate findings and inform tailored policy recommendations for sustainable development. These efforts will deepen our understanding and support more effective strategic planning and policy-making.

Author contributions: Conceptualization, XS and XW; methodology, JC; software, XS; validation, XS, XW and JC; formal analysis, XS; investigation, XS; resources, XS; data curation, JC; writing—original draft preparation, XS; writing—review and editing, XS, YL and GT; visualization, XS; supervision, JC; project administration, XS; funding acquisition, XS. All authors have read and agreed to the published version of the manuscript.

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