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Research on the Spatiotemporal Characteristics and Influencing Factors of Urban Tourism Economic Resilience based on DSR Model

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Abstract

Through literature analysis and synthesis, a comprehensive evaluation index system for urban tourism economic resilience was constructed based on the DSR model. Taking Henan Province as a case study, multiple methods were employed to comprehensively analyze the spatiotemporal evolution characteristics of urban tourism economic resilience. Geographic detectors were used to identify and analyze the factors influencing the development of urban tourism economic resilience. Based on these findings, countermeasures and suggestions are proposed. The conclusions are as follows: From 2011 to 2022, the resilience of the tourism economy in Henan Province exhibited a trend of "first rising, then declining, and subsequently rebounding." There were disparities in the growth rate of tourism economic resilience among cities, and the differences between cities became increasingly pronounced. Spatially, the core development circle centered around "Zhengzhou-Luoyang" is gradually taking shape, showing a significant positive spatial correlation. The resilience of urban tourism economies is influenced by multiple factors. The study found that infrastructure construction, financial self-sufficiency, geographical zoning, economic development level, and tourism development potential are the primary factors driving the spatial differentiation of tourism economic resilience.

Keywords

Urban Tourism Economy Resilience; DSR Model; Spatiotemporal Differentiation; Influencing Factors; Henan Province.

1. Introduction

Over the past forty years of reform and opening up, China's tourism industry has experienced various unexpected events and risks. Among them, the huge impact brought by the outbreak of COVID-19 at the end of 2019 far exceeded the impact caused by previous natural disasters, accidents, economic crises, public health events, etc. [1] In 2022, the number of domestic tourists and domestic tourism revenue were 2.53 billion and 204 trillion yuan, respectively, a decrease of 12.12% and 8.5% compared to 2020, and recovered to 42.1% and 30.7% of 2019, respectively[2]. In response to crisis challenges and adapting to the new development pattern of "domestic circulation as the mainstay and domestic international dual circulation promoting each other", the tourism economy must have sufficient resilience in order to resist shocks, overcome difficulties, and recover quickly, achieve sustainable development of the tourism industry, enhance high-quality development capabilities while tapping into domestic demand, and actively participate in international tourism market competition. Therefore, summarizing and discussing the assessment and construction of the resilience of the tourism economy under the impact of major crises has important practical significance.

Since the concept of "resilience" was introduced, it has been widely applied in industrial fields such as metals, materials science, construction science and engineering, chemistry, and

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machinery to describe the ability of metals to restore their original state under external forces. This perspective on resilience aligns closely with everyday understanding, where resilience is seen as the capacity to return to an original state[3], representing one of the earliest interpretations of the concept. As research progressed, scholars from various disciplines have proposed resilience concepts tailored to their specific research needs. Examples include psychological resilience[4,5], organizational resilience [6], and urban resilience[7]. In the context of regional economics, the concept of resilience was introduced into the economic system [8]. Economic resilience is defined as the ability of an economy to respond to hazards and disturbances, encompassing both the inherent capacity of communities to mitigate negative impacts [9] and the adaptability to withstand economic changes while maintaining living standards [10]. In 2015, Martin et al. [11]provided a more comprehensive and widely accepted explanation of regional economic resilience, emphasizing that resilience is a dynamic process involving multiple elements, including vulnerability, shock, resistance, robustness, and recoverability. Currently, many scholars in academia have directly adopted the concept of regional economic resilience to define tourism economic resilience. Yang Youbao and Wang Rongcheng [12] noted that the tourism economic system is a complex and open system. Its operation must contend with multiple internal and external interferences, as well as inter-industry disruptions, ultimately surviving through a balance between the system's sensitivity and vulnerability to external disturbances and its capacity to respond. This highlights the resilience of the tourism economic system-its ability to recover to an initial or ideal state after being disrupted, which serves as a measure of the sustainable development level of the tourism economy[13].

The modern tourism industry originated in cities and has undergone rapid development over the past century[14]. Today, the boom in urban tourism continues to attract widespread attention both domestically and internationally. As the tourism industry gradually becomes a key driver of the modern service sector, urban tourism has evolved into an emerging industry that optimizes and enhances urban economic structures. Many cities have identified tourism as a pivotal component of their urban economies, making it a significant new source of economic growth. Given that cities account for 80% of global tourism activities, it is crucial to examine how the resilience of their tourism economies performs in the face of crises and how to enhance this resilience. Strengthening the resilience of urban tourism economies, fostering the ability to withstand risks, self-repair, and achieve counter-trend growth, will contribute to promoting the high-quality development of the tourism industry and advancing the strategy of "building a strong tourism nation."

2. Resilience Assessment of Tourism Economy

2.1. Construction of Indicator System

Based on the connotation of resilience in the tourism economy, and following the principles of scientific, comprehensive, and operable indicator system construction, drawing on existing literature research results, and based on the DSR model, a city tourism economic resilience indicator system structure is constructed from three dimensions: driving force, state, and response, as shown in Table 1.

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Table 1. Resilience Index System of Urban Tourism Economy

	First level indicator	Secondary indicators (attributes)
Resilience of tourism economy	Driving force (D)	Tourism revenue as a percentage of GDP C11 (+)
		Tourist reception capacity C12 (+)
		Per capita GDP C13 (+)
		Urbanization level
		The proportion of added value of the tertiary industry is C21 (+)
	Status (S)	Number of star rated hotels C22 (+)
		Number of travel agencies C23 (+)
		Number of A-level scenic spots
		Traffic density C24 (+)
		Per capita park green area C25 (+)
		Excellent air quality with a specific gravity of C26 (+)
		Number of healthcare technicians per 10000 people
	Response (R)	Proportion of tourism professionals C31 (+)
		Talent Reserve in the Tourism Industry C32 (+)
		Informationization level C33 (+)
		Tourism R&D investment intensity C34 (+)

2.2. Research Methods

2.2.1. Entropy Weight TOPSIS Method

Firstly, the entropy weight method is used to determine the indicator weights, and then the TOPSIS comprehensive evaluation method is adopted to fully utilize the original data information, so as to more accurately reflect the degree of deviation of each evaluation object, and thus comprehensively evaluate the resilience level of urban tourism economy.

2.2.2. Kernel Density Estimation

Introduce Kernel density estimation method to explore the dynamic evolution trajectory of tourism economic resilience. Explore the growth, differences, and multipolarity trends of tourism economic resilience through the distribution characteristics, peak height, width, and quantity of kernel density curves.

$$f(x) = \frac{1}{Nh}\sum_{i=1}^{N} K\left(\frac{X_i - x_0}{h}\right) \quad (1)$$

$$K(x) = \frac{1}{\sqrt{2\pi}} exp\left(-\frac{x^2}{2}\right) \quad (2)$$

In the formula, x is a random variable, f (x) is the density function, $X_i$is the observed sample, and $x_0$is the sample mean; h represents the bandwidth, which represents the smoothness of the function fitting. The smaller the value, the higher the accuracy of the estimation result. The bandwidth selection method in this article is$h = 0.9SN^{-0.8}$, where N is the sample standard deviation; K (x) is the kernel function.

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2.2.3. Spatial Correlation Test

To further explore whether there are agglomeration characteristics in the spatial distribution of tourism economic resilience and conduct a comprehensive spatial correlation test, Moran's I found global spatial autocorrelation.

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})\left(x_j - \bar{x}\right)}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \tag{3}$$

Among them, $S^2$is the sample variance, $w_{ij}$is the (i, j)element of the spatial weight matrix, used to measure the distance between region i and region j, $\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}$is the $\bar{x}$sum of all spatial weights, and is the mean of the tourism economic resilience index. The Moran's I index generally ranges from [-1,1], and when Moran's I >0, it indicates positive autocorrelation, meaning that high values are adjacent to high values and low values are adjacent to low values; Moran's I <0 indicates negative autocorrelation, meaning that high values are adjacent to low values. If Moran's I is close to 0, it indicates that the spatial distribution is random.

2.2.4. Geographic Detector

Geographic detector is a statistical method for detecting spatial heterogeneity and revealing the driving forces of influencing factors. This model has no linear assumptions and has a clear physical meaning. It has been applied in multiple fields of natural and social sciences. By calculating the q-value, the explanatory power of the detection factor can be measured and the interaction relationship between variables can be analyzed.

3. Measurement and Analysis of Resilience of Urban Tourism Economy in Henan Province

3.1. Data Sources

Henan Province is located in the Central Plains and has abundant cultural and natural tourism resources. The research object of this article is 18 cities in Henan Province, mainly collecting annual data on relevant indicators of 18 cities, with a research time span from 2011 to 2022. The raw data of the indicators mainly comes from the "Henan Statistical Yearbook (2010-2023)", "Henan Provincial Statistical Bulletin on National Economic and Social Development (2011-2022)", as well as the statistical bulletins on national economic and social development of 18 cities in Henan Province from 2011 to 2022.

3.2. Calculation Results of Urban Tourism Economic Resilience

Overall, the resilience of the tourism economy in Henan Province from 2011 to 2022 shows a trend of "first rising, then falling, and then rebounding", see Figure 1. From 2011 to 2019, the resilience index of the tourism economy steadily increased, rising from 0.205 in 2011 to 0.319 in 2019, with an average annual growth rate of 5.68%. The resilience index declined in 2020 and rebounded in 2021. Although there was a downward trend in 2022, it was still higher than the resilience level in 2020 and lower than in 2019. From a regional perspective, the resilience level of tourism economy in 18 cities in Henan Province shows a similar trend of growth. The resilience level of tourism economy in Zhengzhou, Luoyang, Nanyang and Jiaozuo has always been higher than that of Henan Province, while the resilience level of tourism economy in Kaifeng, Xuchang and Anyang has significantly increased, surpassing the overall level of Henan Province in 2016 and maintaining it.

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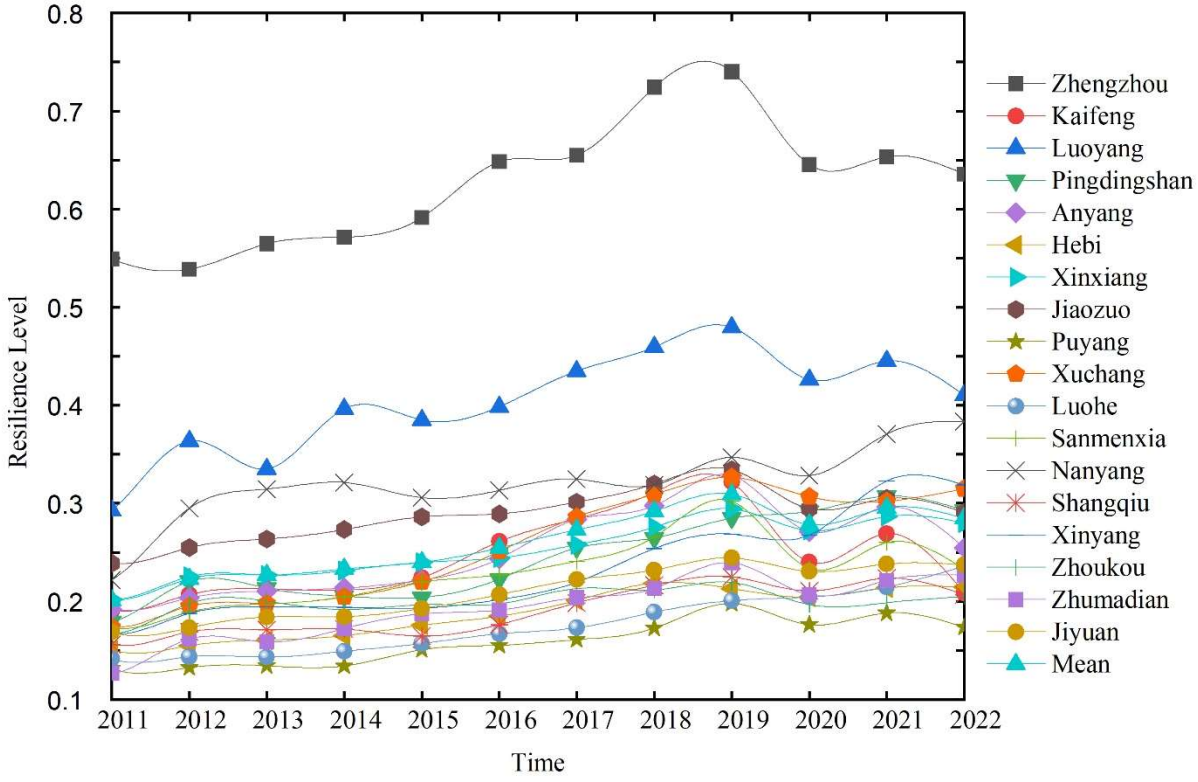

Figure 1. Changing trend of unbar tourism economic resilience in Hennan Province, 2011-2022

3.2.1. Nuclear Density Dynamic Evolution Diagram

To further explore the dynamic evolution characteristics of the resilience of the tourism economy in Henan Province, a kernel density estimation map of the tourism economic resilience index from 2011 to 2022 was drawn using MATLAB software, see Figure 2.

The kernel density analysis of tourism economic resilience across 18 cities in Henan Province reveals four distinct spatial-temporal characteristics:1) Distribution Shift. The rightward shift of the kernel density curve indicates sustained enhancement in tourism economic resilience throughout the province, reflecting promising industry development prospects. This directional movement suggests systemic improvements in tourism infrastructure and service capabilities. 2) Peak Dynamics. The gradual decrease in peak height, accompanied by a morphological transition from leptokurtic to platykurtic distribution, reveals two critical findings: Growing absolute disparities in resilience levels among cities; Emergence of pronounced hierarchical differentiation in tourism economic development. 3) Multi-peak Structure. The trimodal distribution pattern (one dominant peak with two subsidiary peaks) demonstrates: A three-tiered gradient structure in regional tourism development; Initial multi-polarization trends in economic resilience. Post-2015 data shows reduced amplitude in subsidiary peaks, signaling mitigation of inter-city differentiation and potential convergence trends. 4)Right-skewed Distribution. The persistent right-tailed distribution with widening dispersion suggests: Accelerating resilience growth in high-performance cities; Growth inertia in low-performance clusters. This divergence pattern indicates the emergence of "Matthew effects" in tourism development, where advanced cities accumulate competitive advantages more rapidly.

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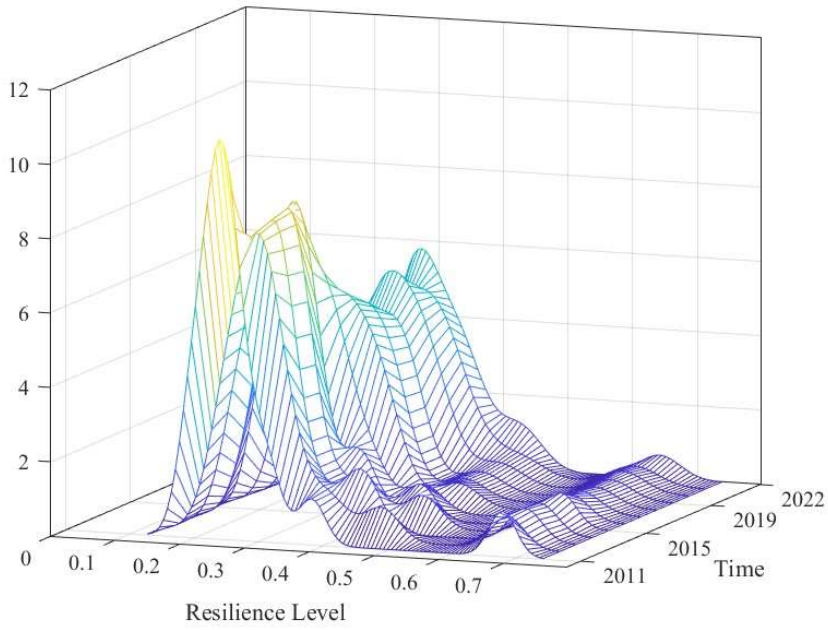

Figure 2. Kernel density estimates of the tourism economy resilience index, 2011-2022

3.2.2. Spatial Distribution Characteristics

Referring to the breakpoint grading method based on existing research results (Shao Xiuying et al., 2022), the resilience of Henan's tourism economy is divided into five levels according to the criteria of low level (C ≤ 0.175), low level (0.175<C ≤ 0.25), medium level (0.25<C ≤ 0.325), high level (0.325<C ≤ 0.4), and high level (C>0.4). The resilience index of tourism economy in 2011, 2015, 2019, and 2022 is selected for spatial visualization analysis, as shown in Figure 3.

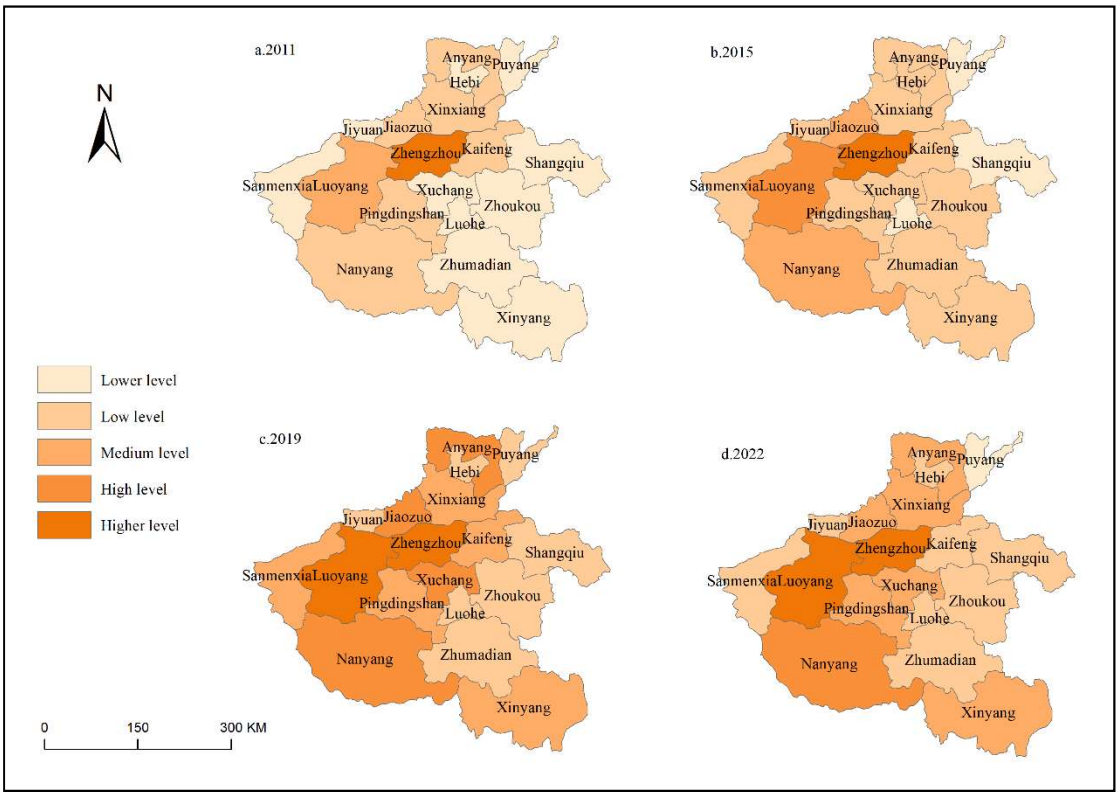

Figure 3. Spatial visualization of the resilience level of the tourism economy in 2015, 2019, and 2022

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Overall, the spatial evolution characteristics of the tourism economy resilience in Henan Province from 2011 to 2022 are relatively pronounced, demonstrating a core development circle effect centered on the "Zhengzhou-Luoyang" region. In 2011, Zhengzhou was at a high level of resilience, Luoyang at a moderate level, while the remaining cities were at low or below-low levels, accounting for 88.89% of the total. By 2015, the resilience level of the tourism economy in seven cities had improved: Luoyang rose to a higher level, Jiaozuo and Nanyang reached a medium level, and Anyang, Hebi, Xuchang, and Xinyang advanced to a lower level. In 2019, both Zhengzhou and Luoyang were at a high level, solidifying the formation of the "Zhengzhou-Luoyang" core development zone. The resilience levels of neighboring cities had also been upgraded to medium or above. However, five cities not adjacent to the core zone—Puyang, Hebi, Shangqiu, Luohe, and Zhumadian—remained at relatively low levels, though no cities were at the lowest level. By 2022, the circle effect of the "Zheng-Luo" core development zone had weakened, primarily due to external shocks. In 2020, the resilience level of the urban tourism economy in Henan Province experienced a significant decline. Although 2021 and 2022 marked a period of economic recovery, the resilience levels remained below those of 2019. The resilience levels in some cities, such as Anyang and Jiaozuo, declined further, largely because the tourism industry constitutes a significant portion of their economic development, and recovery is a time-intensive process.

3.2.3. Spatial Correlation

Using STATA software to calculate the global Moran index, further explore the spatial correlation characteristics of tourism economic resilience, as shown in Table 2.

Table 2. Moran's I

Variables	I	z	p-value*
2011	0.094	1.586	0.056
2012	0.100	1.289	0.099
2013	0.086	1.238	0.108
2014	0.107	1.316	0.094
2015	0.115	1.458	0.072
2016	0.112	1.510	0.065
2017	0.115	1.443	0.075
2018	0.123	1.588	0.056
2019	0.121	1.532	0.063
2020	0.125	1.550	0.061
2021	0.121	1.434	0.076
2022	0.104	1.299	0.097

*1-tail test.

Except for 2013, the global Moran's I of tourism economic resilience in all other years passed the test at a 90% confidence level, showing significant spatial positive correlation. Overall, Moran's I showed an upward trend from 2011 to 2022, indicating an increased spatial correlation in the resilience of the tourism economy in Henan Province during the research period. Specifically, from 2011 to 2015, Moran's I experienced a significant increase, and its spatial agglomeration characteristics gradually strengthened; From 2016 to 2019, Moran's I experienced a decline and the clustering characteristics weakened; From 2020 to 2022, Moran's I has rebounded and its spatial agglomeration characteristics have strengthened.

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3.3. Analysis of Influencing Factors

3.3.1. Identification of Influencing Factors

The development of resilience in urban tourism economy is influenced by multiple factors, including not only internal systems but also external factors and other unquantifiable factors. Based on the resilience index system of the tourism economy and existing research results, influencing factors were selected from seven levels: the level of economic development, economic structure, tourism development potential, infrastructure construction, financial self-sufficiency level, geographical zoning, and tourism market size of the city [15,16,17,18]. The specific factor indicators are shown in Table 3.

Table 3. Indicators of Influencing Factors

Influence factor	Indicator Description	Code
Economic development level	Logarithmic representation of regional gross domestic product	X1
economic structure	The proportion of the third output value to the second output value	X2
Potential for tourism development	You Jubi	X3
Infrastructure construction	Take the logarithm of the total passenger volume in society	X4
Financial self-sufficiency level	Proportion of fiscal expenditure to regional GDP	X5
Geographical zoning	North Henan, West Henan, Southwest Henan, Central Plains Urban Agglomeration, Huang Huai[19]	X6
Scale of tourism market	Take the logarithm of the permanent resident population in the region	X7

3.3.2. Result Analysis

Table 4. Single factor analysis

	q statistic	p value
X1	0.221	0.0047
X2	0.127	0.0295
X3	0.162	0.0021
X4	0.324	0.0000
X5	0.295	0.0000
X6	0.269	0.0000
X7	0.064	0.5368

For the resilience of the urban tourism economy in Henan Province, the explanatory power (q-values) of various influencing factors, ranked from strong to weak, is as follows: X4 > X5 > X6 > X1 > X3 > X2 > X7, see Table 4. Infrastructure construction (X4) exhibits the strongest explanatory power for the resilience of the tourism economy in Henan Province, with a q-value of 0.324. This indicates that urban infrastructure construction serves as a critical foundation and guarantee for the development of the tourism economy. In contrast, the tourism market size (X7) has the weakest explanatory power, with a q-value of 0.064. Among the factors, X4, X5, X6, X1, and X3 passed the significance test at a 99% confidence level, while X2 and X7 did not. Infrastructure construction, financial self-sufficiency level, geographical zoning, economic development level, and tourism development potential are the primary factors driving the spatial differentiation of tourism economic resilience in Henan Province.

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The level of infrastructure construction directly reflects a city's public service capabilities and its commitment to humanistic care, exerting the most immediate impact on tourists. The government's financial self-sufficiency level indicates the efficiency of a city's operations and directly influences the resilience of its tourism economy. Tourism resources, shaped by terrain, topography, and climate, vary across geographical regions, leading to differences in their attractiveness to tourists. The development of the tourism industry is closely tied to the city's economic development level, which provides essential support for the industry's growth. Consequently, regions with faster economic development tend to experience more rapid tourism development, thereby enhancing the resilience of their tourism economy. Additionally, the tourism-to-residential ratio serves as an intuitive indicator of the urban tourism industry's development potential. Greater tourism development potential is more conducive to improving the resilience level of the urban tourism economy.

4. Conclusion and Suggestions

4.1. Conclusion

Taking Henan Province as an example to explore the resilience of urban tourism economy, the following conclusions are drawn:

(1) Overall, from 2011 to 2022, the urban tourism economy resilience of Henan Province showed a trend of "first rising, then falling, and then rebounding", with differences in the acceleration of tourism economic resilience among cities, and the differences between cities becoming increasingly evident.

(2) The spatial evolution characteristics of the resilience of tourism economy in Henan Province are relatively obvious, and the spatial effect of the core development circle centered on "Zhengzhou-Luoyang" is gradually forming, showing significant spatial positive correlation.

(3) The resilience of urban tourism economy is influenced by multiple factors. Research has found that infrastructure construction, financial self-sufficiency level, geographical zoning, economic development level, and tourism development potential are the main factors affecting the spatial differentiation of tourism economic resilience.

4.2. Suggestions

Based on the previous analysis, the following suggestions are proposed to enhance the resilience of urban tourism economy:

Firstly, strengthen regional cooperation and narrow regional disparities. Cities in Henan Province should break down administrative barriers, establish communication and coordination mechanisms between different regions, and strengthen regional collaborative cooperation through resource integration. Northern, Central, Southern, Eastern, and Western Henan should uphold the development concept of cooperation and win-win, and form a regional linkage for tourism development.

Secondly, fully leverage the radiating and driving effect of the central city on surrounding cities. On the one hand, central cities in Henan Province such as Zhengzhou and Luoyang fully utilize and leverage their economic foundation, location conditions, resource endowments, and other advantages to further promote the development of the tourism industry; On the other hand, building effective learning and dissemination channels and mechanisms, continuously amplifying the spillover effects of tourism industry development in central cities such as Zhengzhou and Luoyang, and generating radiation demonstration effects on surrounding cities through effective output of capital, technology, talent, etc., to promote the development of tourism industry in surrounding cities.

Thirdly, pay attention to the capacity building of the main influencing factors. In the interaction of influencing factors, infrastructure construction, financial self-sufficiency level, geographical

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zoning, economic development level, and tourism development potential play a significant driving role in the resilience of urban tourism economy. Cities can take a series of measures to strengthen the construction of tourism transportation roads and supporting facilities, improve the efficiency of fund utilization, and reasonably allocate tourism related resources in their development. By optimizing relevant influencing factors more efficiently, resistance and recovery can be improved, thereby rapidly enhancing the resilience of urban tourism economy.

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