

Measurement and Spatiotemporal Analysis of Tourism Economy Resilience in Hunan Province

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ABSTRACT

Frequent crisis events make us realize that we must improve the anti-risk ability of tourism economy. This study establishes an evaluation system from four dimensions (resistance, resilience, reorganization and renewal/transformation). We used entropy weight method and GIS tools to measure the temporal and spatial changes of tourism economic resilience of 13 cities in Hunan Province from 2013 to 2023, and also analyzed the driving mechanism behind it with geographic detectors. The main findings are as follows: (1) In time, the overall toughness is rising. Changsha has been stable (index > 0.85), while Zhangjiajie, which relies on tourism resources, dropped sharply (from 0.34 to 0.25) during the epidemic, while Chenzhou increased steadily. (2) In space, the toughness presents a pattern of "high in the center and low in the periphery" and "high in the east and low in the west". (3) In terms of mechanism, the proportion of tertiary industry and the excellent rate of air quality are the main driving factors, and government intervention and infrastructure also play a supporting role. Finally, the study puts forward policy suggestions for regional collaborative governance and industrial upgrading.

Keywords: Hunan Province, tourism economy, resilience, entropy weight method, spatiotemporal differentiation

1. INTRODUCTION

The research on tourism economic resilience is to apply the theory of regional economic resilience in a special industry-tourism. The concept of economic resilience was first engineering resilience, then it became economic resilience, and then it developed into evolutionary resilience. This evolutionary view emphasizes that the economic system not only has the ability to resist shocks and recover, but also can actively carry out structural adjustment and innovative transformation. It is particularly meaningful to apply this theoretical framework to tourism research, because tourism itself has the characteristics of sensitive demand, strong industry correlation and obvious seasonality^[1]. These characteristics make it show its unique vulnerability and recovery mode in the face of financial crisis, public health events and natural disasters. In recent years, global crises like COVID-19 pandemic have further made people see the urgency and practical value of studying tourism economic resilience.

2. LITERATURE REVIEW

2.1 Six Theoretical Dimensions of Economic Resilience

2.1.1 Resistance Capacity

It means that the system can withstand the impact and will not let the core functions collapse. Key indicators include economic diversity index, fiscal buffer reserve, and reserve capacity of important infrastructure^[2]. For example, industrial diversification is considered as the most important buffer mechanism to spread risks.

2.1.2 Recovery Capacity

Measure the speed and degree of a system returning to the state before impact or reaching a new balance^[3]. The commonly observed indicators include the rebound of employment rate, GDP growth rate and the number of tourists. Recovery depends not only on external assistance, but also on the capital stock and market vitality within the system.

2.1.3 Adaptive Capacity

It reflects the dynamic process of internal adjustment of a system in response to continuous pressure^[4]. This includes adjusting the company's operating strategy, retraining employees and using policy tools flexibly. This adaptation process emphasizes continuous learning and improvement bit by bit.

2.1.4 Transformative Capacity

Represents the basic ability of a system, which can take advantage of the opportunities brought by the crisis to make structural changes and develop in a more sustainable direction. This includes technological innovation, institutional restructuring, and the emergence of new business models ^[5]. Transformation is not just "returning to the original appearance", but pursuing upgrading after "creative destruction".

2.1.5 Learning and Innovation Capacity

It is the core engine for building long-term compressive capacity. It refers to the cumulative process of a system learning from shocks and improving its future coping ability through R&D investment, knowledge spillovers and collaborative networks. Innovation is the basis of adaptation and transformation.

2.1.6 Governance and Institutional Capacity

We are concerned about the ability of multiple participants to plan and manage together, and they enhance their resilience through some institutional arrangements, cooperation mechanisms and collective actions. Good multi-level governance can integrate various resources and reduce the uncertainty when dealing with problems.

2.2 Five Key Research Themes in Tourism Economic Resilience

2.2.1 Conceptualization and Measurement System Development

Tourism economic resilience refers to the comprehensive ability of a tourist destination to maintain normal operation, reduce losses and become better. The method of measuring it has also been improving, from using only a single index at the beginning, to now there are comprehensive index method, network analysis method (that is, analyzing the topological structure toughness of tourism industrial clusters) and econometric model ^[6].

2.2.2 Identification of Key Driving Mechanisms

Research shows that the resilience of tourism is affected by many factors, such as diversification of industrial structure: diversification of products, markets and income sources can greatly enhance the resistance ^[7]. Social capital and action: the unity spirit of the community, entrepreneurial spirit, and the cooperation network between the government and enterprises are all important resources to deal with the crisis. Digital technology and infrastructure: Smart tourism platform, digital marketing tools and solid physical infrastructure constitute the technical foundation for adaptation and recovery. Institutional environment and policy response: flexible crisis management, fair rescue policy and long-term industrial strategic planning provide institutional support ^[8].

2.2.3 Shock Specificity and Spatial Heterogeneity

Research shows that different types of shocks (such as acute and chronic, global and local) will affect tourism in different ways. At the same time, the recovery capacity is very different in space-due to the different resources, economic structure and governance capacity, the recovery characteristics of urban commercial areas, coastal resorts and rural eco-tourism areas are also different ^[9]. This shows that the study of Hunan Province should pay attention to the differences between Changsha-Zhuzhou-Xiangtan urban agglomeration and Greater Xiangxi ecological zone.

2.2.4 Recovery Pathways and Transformation Strategies

It is found that there are several different modes of economic recovery, such as V-type, U-type and L-type. After the epidemic, people pay more attention to how to achieve high-quality development through green transformation, digital technology, experience reshaping and regional cooperation ^[10].

2.2.5 Multi-scale Case Studies and Comparisons

Case studies cover global destinations (such as Bali and Orlando), national level (such as New Zealand and Iceland) and regional scope (such as the Mediterranean coast and the Alps), which constantly verify and enrich the applicability of the resilience theory. In recent years, the research on the background of China has become more and more, but the in-depth analysis of the central region like Hunan Province is not enough ^[11].

3. RESEARCH METHODS AND DATA SOURCES: CONSTRUCTION OF THE INDICATOR SYSTEM AND THE ENTROPY WEIGHT METHOD

3.1 Construction of the Evaluation Indicator System

According to the existing research, we have established an analytical framework including four aspects-resistance, Recovery, reconstruction and transformation-to evaluate the tourism economic resilience of Hunan Province. Some specific indicators are selected below for each aspect. Please see Table 1 for details.

Table 1. Tourism Economic Resilience Evaluation Indicator System for Hunan Province

Primary indicator	Secondary indicator	unit
Immunity	Total tourism revenue	Biillion yuan
	Total number of tourists received	Ten thousand
	The number of A-level scenic spots	number
	Per capita GDP	yuan
Resilience	The number of five-star hotels	number
Reconstructive force	Tourism and Culture-related Fiscal	Biillion yuan
	Expenditure	
Transformational Power	The proportion of the tertiary industry	percent
	Road density	One hundred square kilometers
	Air quality excellent rate	percent

3.2 Entropy Weight Method

To objectively determine indicator weights, the entropy weight method is employed, which avoids subjective bias^[12]. The calculation steps are as follows:

(1) Data Standardization

To unify the differences in the units of each indicator, the original data is first standardized. Since all selected indicators are positive indicators, the standardization method for positive indicators is used.

$$y_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \quad (1)$$

y_{ij} is the standardized value of the j -th evaluation indicator for the i -th evaluation object.

(2) Calculation of Each Indicator's Weight

$$p_{ij} = \frac{x_{ij}}{\sum x_{ij}} \quad (2)$$

(3) Calculation of Information Entropy

The greater the differences in the indicator data, the higher its entropy value, indicating that the information content of this indicator is higher. The formula for calculating information entropy is:

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

(4) Calculation of Each Indicator's Difference Coefficient

$$G_j = 1 - E_j \quad (4)$$

(5) Calculation of Each Indicator's Weight

$$W_j = \frac{G_j}{\sum_{j=1}^m G_j} \quad (5)$$

This paper constructs a comprehensive evaluation index of the digital economy development level in Hunan Province by performing a weighted calculation of the specific values and corresponding weights of the above indicator system. The calculation formula is as follows:

$$Y_{ij} = y_{ij} * W_j \quad (6)$$

Where Y_{ij} is the comprehensive index of digital economy development level, W_j is the weight of each indicator after applying the entropy weight method, and y_{ij} represents the various indicators measuring the level of digital economy development.

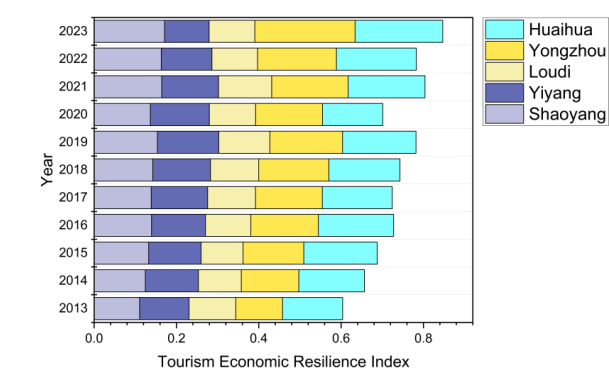
3.3 Data Sources

The research covers 13 prefecture-level cities in Hunan Province (excluding Xiangxi Prefecture) from 2013 to 2023. Data are sourced from the Hunan Statistical Yearbook, statistical bulletins of various cities, and the official websites of relevant government departments.

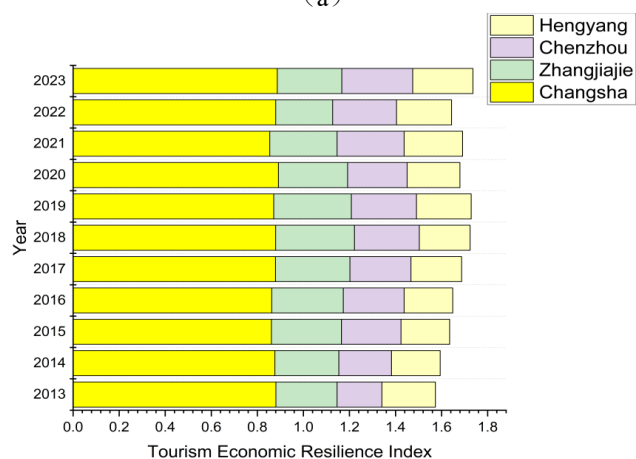
4. TEMPORAL AND SPATIAL EVOLUTION OF TOURISM ECONOMIC RESILIENCE IN HUNAN PROVINCE

4.1 Temporal Evolution Characteristics

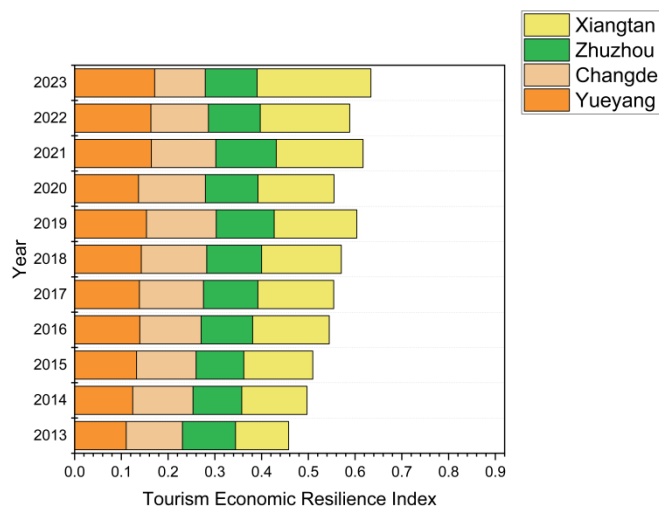
We use entropy weight method to analyze the tourism economic resilience indicators of 13 cities in Hunan Province from 2013 to 2023. From the time point of view, as the provincial capital, the index of Changsha is stable above 0.85 every year, which shows that it is particularly stable and resilient, with a solid foundation of tourism economy and strong ability to resist risks. It even reached the highest point of 0.89 in 2020 at the beginning of the epidemic, showing strong emergency adaptability. Most other cities, such as Chenzhou, Hengyang and Yongzhou, have been rising slowly in the past decade. For example, the index of Chenzhou has risen from 0.19 to 0.31, which shows that they have made great progress in optimizing the tourism structure and coping ability. It is particularly noteworthy that the index of Zhangjiajie dropped significantly from 0.34 to 0.25 from 2020 to 2022, which has a lot to do with the impact of the epidemic on those places that rely on natural scenery and group tourism.



(a)



(b)



(c)

Figure 4-1. Changes of tourism economic resilience index in some cities (2013-2023), including (a), (b) and (c).

4.2 Spatial Distribution Pattern

From a spatial point of view, the resilience of the tourism economy in Hunan Province shows an obvious distribution pattern of "high center and low periphery". As a core city, Changsha continues to lead the province in terms of resilience index, forming an obvious core area with high resilience. The resilience level of some cities in central and eastern Hunan such as Zhuzhou, Xiangtan, and Hengyang is in the middle range, and has improved over time, but there is still a certain gap with Changsha. Some cities in western and southern Hunan such as Zhangjiajie, Xiangxi Prefecture, and Yongzhou are relatively weak, especially under external shocks. It is worth noting that although Zhangjiajie is rich in tourism resources, its tourism economic resilience has declined significantly during the epidemic, reflecting the spatial fragility of a single tourism structure. In addition, the province has not yet formed an obvious resilience synergy improvement area, and the resilience level between cities varies significantly, and the spatial linkage effect is insufficient.

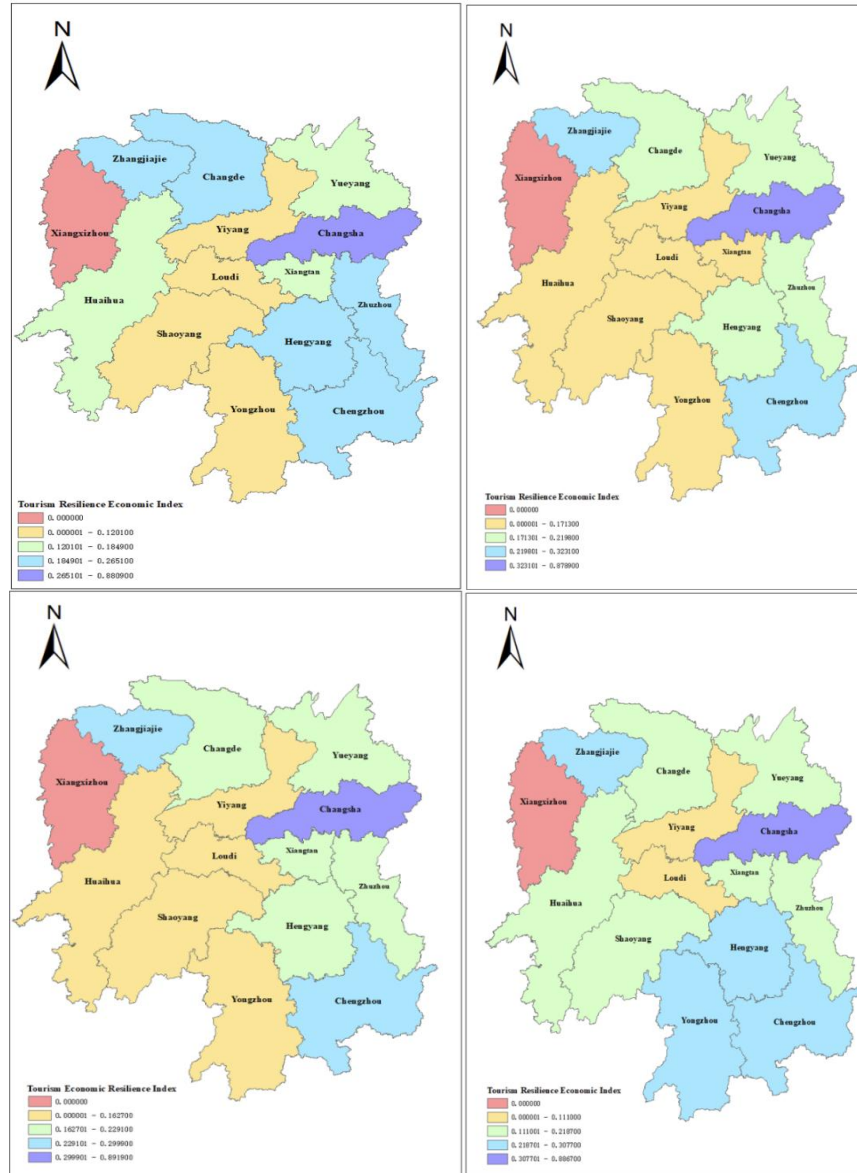


Figure 4-2. Spatial Distribution of Tourism Economic Resilience in Hunan Province (2013、2016、2020、2022)

4.3 Overall Trends and Core Shortcomings

On the whole, most cities will still remain resilient or gradually rebound after 2020, such as Yongzhou reaching 0.24 in 2023, a ten-year high, indicating that Hunan tourism as a whole has shown strong self-adjustment and recovery ability after the epidemic. However, the indexes of Yiyang, Loudi and other places have fluctuated or stagnated slightly in the past two years, revealing that there is still room for improvement in the tourism economic structure and anti-risk mechanism of these regions.

Table 2. Tourism Economic Resilience Index (a)

	Changsha	Zhangjiajie	Chenzhou	Hengyang	Yueyang	Changde	Zhuzhou
2013	0.8809	0.2651	0.1949	0.2323	0.1849	0.2016	0.1975
2014	0.8761	0.2776	0.2290	0.2114	0.1816	0.2165	0.1920
2015	0.8614	0.3039	0.2585	0.2113	0.1778	0.2210	0.1874
2016	0.8624	0.3109	0.2642	0.2109	0.2028	0.2212	0.1968
2017	0.8789	0.3231	0.2650	0.2198	0.2049	0.2185	0.1988
2018	0.8795	0.3423	0.2814	0.2205	0.2110	0.2272	0.2097
2019	0.8708	0.3376	0.2825	0.2374	0.2061	0.2155	0.2289
2020	0.8919	0.2999	0.2588	0.2291	0.2076	0.2086	0.2193
2021	0.8539	0.2921	0.2913	0.2541	0.2153	0.2052	0.2167
2022	0.8801	0.2470	0.2772	0.2390	0.1754	0.1768	0.2112
2023	0.8867	0.2802	0.3077	0.2616	0.2050	0.1969	0.2187

Table 2. Tourism Economic Resilience Index (b)

	Xiangtan	Shaoyang	Yiyang	Loudi	Yongzhou	Huaihua
2013	0.1614	0.1105	0.1201	0.1136	0.1137	0.1459
2014	0.1686	0.1244	0.1290	0.1042	0.1396	0.1595
2015	0.1660	0.1325	0.1273	0.1022	0.1475	0.1783
2016	0.1649	0.1394	0.1312	0.1103	0.1638	0.1830
2017	0.1713	0.1386	0.1371	0.1165	0.1622	0.1699
2018	0.1749	0.1425	0.1401	0.1174	0.1705	0.1725
2019	0.1861	0.1537	0.1492	0.1241	0.1767	0.1784
2020	0.1795	0.1368	0.1431	0.1125	0.1627	0.1463
2021	0.1710	0.1642	0.1380	0.1293	0.1857	0.1867
2022	0.1716	0.1633	0.1230	0.1109	0.1914	0.1942
2023	0.1747	0.1712	0.1082	0.1110	0.2435	0.2130

Finally, the analysis reveals two core shortcomings of the current resilience construction: one is the lack of structural resilience, and the other is the lack of regional coordination. Most cities' tourism economy is too dependent on specific resources or markets, and lacks buffer and substitution momentum. At the same time, the province has not yet formed a resilient network with Changsha as the core, effective radiation driving the surrounding area, risk sharing and opportunity sharing. The coexistence of Changsha's high resilience and the low resilience of surrounding cities indicates that the diffusion effect of the growth pole has not been effectively transformed into the overall resilience improvement of the region. Overall, the overall resilience of Hunan's tourism economy has improved in the past decade, especially under external shocks, but regional differences still exist, and balanced development and resilience can be further promoted in the future.

5. ANALYSIS OF INFLUENCING FACTORS USING THE GEOGRAPHICAL DETECTOR

To explore the driving factors behind the spatial differentiation of tourism economic resilience, the optimal parameter geographical detector model was employed. The results indicate that financial capital, government intervention, infrastructure, and market scale jointly affect tourism economic resilience through different pathways, forming an evolutionary trend dominated by government intervention and supplemented by infrastructure.

According to the analysis of weight proportions within the evaluation system, the increase in the proportion of the tertiary industry and the excellent air quality rate are the dominant factors influencing the spatial differentiation of tourism

economic resilience in Hunan Province. This shows that diversified economic structure (turning to service industry) plays a core role in dispersing risks and improving the buffering capacity of the system. High-quality ecological environment is not only the key to attract tourists, but also reflects the ability of sustainable development, which constitutes an important basis for the ecological dimension of resilience.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Main Conclusions

Spatio-temporal differences: The tourism economic resilience of Hunan Province shows obvious temporal and spatial differentiation, showing the characteristics of "high in the east and low in the west" and "leading in the middle". Changsha is highly resilient because of its diversified economy, strong government support and strong infrastructure. In contrast, a resource-dependent area like Zhangjiajie is obviously vulnerable to systemic shocks. Responses to shocks vary from place to place: COVID-19 epidemic is like a stress test, which shows that different cities have different coping capacities. Cities with a good foundation like Changsha show high emergency adaptability, while places like Huaihua and Shaoyang are stable although they have a low starting point. However, as Loudi and Yiyang have some fluctuations, it is particularly important to cultivate transformation and learning ability to cope with future uncertainty.

Main influencing mechanism: We find that diversified industrial structure and high-quality ecological environment (such as air quality) are the main reasons for the difference in urban resilience. Government intervention and infrastructure, like key backing, can help start and accelerate recovery in a crisis.

6.2 Policy Recommendations

Enhance the radiation function of the core growth pole: consolidate Changsha's role as the "core engine" of the province's tourism resilience. Establish mechanisms such as "Changsha Metropolitan Area Tourism Resilience Alliance" to promote collaborative planning, resource sharing and joint emergency response with surrounding cities, thus narrowing the resilience gap between the core area and the peripheral area.

Promote industrial diversification and upgrading: cities that rely on resources like Zhangjiajie should actively shift from a single sightseeing model to a composite model that combines leisure, vacation, recreation and cultural creativity. Develop new products, use digital technology to expand the off-season market and increase added value.

Strengthen regional coordination and collaborative governance: promote inter-city tourism cooperation by integrating marketing, sharing tourist routes and unifying crisis management plans. Establish a province-wide tourism resilience monitoring and early warning platform to facilitate information sharing and collaborative response.

Increase strategic financial support and green investment: guide funds to support small and medium-sized tourism enterprises, digital transformation projects and sustainable infrastructure construction. Link financial support with green performance indicators to encourage the transformation to high-quality and sustainable tourism development.

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