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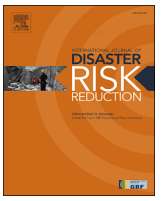

Analysing the differential impact of the COVID-19 pandemic on the resilience of the tourism economy: A case study of the Chengdu-Chongqing urban agglomeration in China

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ABSTRACT

The outbreak of the COVID-19 pandemic in 2019 had a profound impact on the tourism economy, underscoring the critical importance of assessing and analyzing tourism economic resilience. Traditionally, prior research predominantly focused on constructing evaluation systems based on three dimensions: Risk preparedness capability, Restoration capability, and Reorganization and modernization capacity. In this study, we take an innovative approach by incorporating urban network thinking and establishing a tourism economic network, while introducing the dimension of "The rationality of network structure." To comprehensively understand the dynamics of tourism economic resilience, we divided the period from 2018 to 2021 into three distinct phases: Stable period, Pre-shock period, and Shock period. This division allowed us to conduct comparative research that highlights the variations in tourism economic resilience across these different time frames. Additionally, we employed advanced methods, such as kernel density estimation and the GTWR model, for empirical analysis of tourism economic resilience within the Chengdu-Chongqing city cluster. The results of our research unveiled that Chengdu and Chongqing both demonstrate a remarkable level of resilience within their tourism economies. However, given their status as the "dual core" of the Chengdu-Chongqing city agglomeration, they are inherently more susceptible to significant fluctuations when confronted with shocks. The spatial pattern of tourism economic resilience is characterized by prominent wings on both sides, a North-South balance, and a central region with vulnerabilities. The predominant evolutionary patterns are marked by multi-level stabilization, moderate growth, and moderate decline. Ziyang is an exceptional region within the broader growth zone, and its reduced risk preparedness capability has led to an overall decline in tourism economic resilience. Furthermore, key influencing factors, including the economy, infrastructure, and ecological environment, exhibit significant spatial heterogeneity. In conclusion, our study offers valuable insights into researching tourism economic resilience under external shocks, such as the COVID-19 pandemic. These findings can be instrumental in guiding policymakers as they develop effective strategies to bolster tourism economic resilience.

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1. Introduction

In 2020, the tourism industry faced a substantial decline due to the global spread of the novel coronavirus and changes in the external environment. This decline led to a significant 43 % decrease in the number of international travellers worldwide compared to the previous year, i.e., 2019. While China made commendable efforts in preventing and controlling COVID-19, importantly, the implementation of "closed" or "semi-closed" management strategies resulted in a notable reduction in population mobility and economic activity. The tourism industry heavily depends on tourist flow, but extended lockdowns and travel restrictions severely hindered Chinese tourism growth [1]. Additionally, the tourism industry is intricately connected to and collaborates with various other sectors. The emergence of the COVID-19 pandemic had a "negative correlation" effect on the overall national economy, impacting various dimensions of the tourism industry. As a labour-intensive industry with inherent fragility, tourism relies on the spatial mobility of tourists [2]. Consequently, China's adoption of stringent management policies to curb the pandemic significantly impacted the tourism sector. Given the increasingly complex and ever-evolving socio-economic landscape, the concept of resilience has become crucial for the survival of the tourism sector in the face of diverse challenges. Enhancing tourism sector resilience is a vital step in promoting inclusivity and flexibility within the industry. It also represents a critical pathway for ensuring the safety and long-term growth of the tourism sector in the years to come [3].

As a vital economic growth hub in Southwest China, the Chengdu-Chongqing urban agglomeration plays a pivotal role in the region's development. It acts as a new land-sea nexus for extending the Three Horizontal and Two Vertical Urbanization Strategy into the western region. The development and prosperity of this urban agglomeration are intricately linked with the economic security and sustainable growth of the entire western region. In recent years, the tourism industry has seen unprecedented growth, owing to the rapid advancement of the Internet and social media, which have enabled the extensive promotion of the region's tourist attractions and culture [4]. In this favourable context, the consequences of the COVID-19 pandemic have emerged as a significant challenge. Given the profound impact of the pandemic, it is essential to devise measures tailored to the diverse resilience capacities exhibited by different cities.

Based on a thorough review of the literature, it is evident that research on the elasticity of Chinese tourism economy is still in its nascent and exploratory phases. In contrast, on an international level, there is a more advanced beginning with some substantial research accumulated in related fields [5–7]. Fabio Mazzola focuses on measuring the tourism economic resilience of island economies and assessing their role in economic crises [8]. Mesbahuddin Chowdhury's research delves into the resilience of New Zealand's tourism enterprises in the aftermath of disasters, aiming to identify critical elements within social capital that can elevate resilience levels and foster inter-organizational connections [9]. Tarik Dogru, on the other hand, investigates the resilience and vulnerability of the tourism industry within the context of climate change. His study takes into account non-climate factors such as agriculture, urban and rural populations, and quality of life indicators [5]. Additionally, Elizabeth A. Cartier takes 416 wildfires as a case study to interpret community responses to crisis management from a resilience perspective. This approach offers a more intuitive understanding of the resilience process in the tourism industry and its connection to tourism crisis management and sustainability [10].

Currently, due to the relatively late start of research in China, the field of tourism studies lacks sufficient attention to resilience, and improvements in the research system are necessary. Yang Xiuping and colleagues, taking Lanzhou as a case study, employ resilience theory to investigate urban tourism environmental systems [11]. Their innovative approaches aim to establish a win–win situation for protecting urban tourism environmental systems and promoting urban tourism development. Additionally, Fang Yelin's research focuses on measuring provincial tourism economic resilience from 1998 to 2020. He analyses the role of tourism economic resilience in facilitating high-quality tourism development from a broader perspective and explores the implications of tourism economic resilience [12]. Moreover, in their research, some scholars integrate inbound tourism with economic resilience. They suggest that inbound tourism economic resilience and growth are mutually reinforcing in a virtuous cycle [13]. Building on this suggestion, Wang Xinyue conducts a spatiotemporal evolutionary analysis and configuration feature research on the inbound tourism economic resilience of Chinese provinces, drawing on Martin's economic resilience theory [14].

Based on the summary and analysis of the literature above, we identify several areas where tourism economic resilience research can still be improved. First, there is a need for more comprehensive quantitative research on tourism economic resilience during crisis situations. Second, regarding research methods, while the construction of indicator systems and core variable selection methods is primarily aimed at evaluating tourism economic resilience, there is room for improvement in terms of the rationality and comprehensiveness of the constructed indicator systems. Additionally, from a research scale perspective, most quantitative studies are concentrated at the national or provincial levels, with limited research into internal driving mechanisms.

This paper primarily focuses on addressing the aforementioned issues identified in previous studies and aims to optimize and enhance the following aspects. The social network analysis method employed in this study, based on urban network thinking, has gained popularity in recent research. Currently, research on network structures across various spatial scales is on the rise. Such research encompasses the study of urban economics [15], population mobility [16], and urban transportation [17], as well as comprehensive research involving multiple network types, including financial networks, information networks, and knowledge networks [18]. In the realm of tourism research, Fang Yelin constructs a tourism flow network using data from tourism routes. He evaluates the resilience of tourism flow network structures in the five major coastal city clusters in Eastern China, considering attributes such as "hierarchy," "matching," "transitivity," and "agglomeration" [19]. In contrast to prior studies that exclusively concentrated on researching network structure resilience and relied on conventional indicators for assessing tourism economic resilience, this paper introduces a novel approach. It integrates network structure metrics into a comprehensive evaluation system while incorporating the principles of urban network thinking. This integration not only augments the scientific precision of tourism economic resilience assessment but also provides a more holistic perspective. This innovative approach aims to uncover the underlying issues within the study area by

utilizing the relatively abstract characteristics of the network structure. We employ the geographically and temporally weighted regression (GTWR) model to analyse the influencing factors using data from consecutive time periods. This model incorporates both temporal and spatial elements for a comprehensive analysis. Unlike studies that cover a broader geographical area, this research focuses specifically on prefecture-level cities. This refined scope enables a more accurate and comprehensive depiction of the region's tourism economic resilience, providing valuable scientific insights to advance the local tourism industry and inform local policy formulation.

The research focuses on the Chengdu-Chongqing urban agglomeration as the study area and designates 2018 as the stable period, 2019 as the pre-shock period, and 2020 as the shock period. The application of the entropy weight technique for order of preference by similarity to ideal solution (TOPSIS) method involves constructing an evaluation system based on four dimensions: risk resistance ability, recovery ability, reorganization and renewal ability, and network structure rationality. The analysis of the spatiotemporal evolutionary characteristics of tourism economic resilience utilizes kernel density estimation and ArcGIS spatial analysis. Additionally, the examination of influencing factors is conducted by applying the GTWR model. This research has the following objectives: (1) to assess and analyse the resilience of the tourism economy in the Chengdu-Chongqing urban agglomeration at three stages—the stable period, pre-shock period, and shock period—to identify sensitive areas and development trends in the region's tourism industry; and (2) to investigate the elements that influence tourism economic resilience and their regional variability, aiming to provide a scientific reference for identifying reasonable approaches to improve resilience.

The rest of this paper is structured as follows: Section two of this study offers a comprehensive review of the literature regarding the economic resilience of tourism. Subsequently, section three outlines the research methodology employed in this study, along with a detailed description of the indicator system utilized. In the fourth section, a thorough analysis of the empirical research findings is presented. The study concludes by summarizing the key conclusions drawn from the research, and it initiates a thoughtful discussion and reflection on the implications of the findings.

2. Literature review

2.1. The concept and application of resilience

The term “resilience” initially denoted the capacity of a physical object to restore its original state following an impact. In recent years, scholars have shown significant interest in the ability to effectively navigate sudden changes and shocks, given the growing complexity of global and regional natural and socio-economic environments. The concept of resilience has evolved through three primary stages in its developmental process, namely, engineering resilience, ecological resilience, and evolutionary resilience [20]. During its initial phases, the application of resilience in the field of biology focused on examining the ability of ecosystems to recover. This focus ultimately gave rise to the notion of ecological resilience [21]. Subsequently, as the theoretical framework continued to evolve, the concept of resilience found its way into various academic fields, such as spatial economics [22] and other related disciplines [23–25]. In recent years, there has been growing scholarly interest in resilience research due to the emergence of persistent stressors and sudden disruptive events. Research on resilience has been conducted from diverse vantage points, encompassing policy systems, economic circumstances, ecological surroundings, and infrastructure [26–28]. Chinese scholars have been actively engaged in resilience research, conducting in-depth analyses of the concept and its significance, along with quantitative studies at various spatial scales, such as the national, urban agglomeration, and economic belt levels. They have employed a range of methodologies to assess different dimensions of urban resilience, including indicator systems, resilience maturity models, layer overlay methods, remote sensing model evaluation, and social network analysis [29–31]. In addition, some researchers have analysed the spatiotemporal evolution and spatial spillover effects of resilience [32,33].

2.2. Resilience of the tourism economy under the impact of COVID-19

Different research perspectives and the ongoing deepening of resilience studies have led to the evolution of the connotation of regional economic resilience. Drawing from the research of scholars such as Simmie [34] and Martin [35], Liangang L and others have proposed that regional economic resilience encompasses the capacity of a regional economic system to withstand shocks and disturbances from the market and the environment. It also includes the ability to swiftly recover and potentially transition to a more optimal development path through adjustments and adaptations [36]. In the realm of tourism, economic resilience is an integral part of the recovery process for the tourism economic system and cannot be viewed in isolation from the tourism industry. The synergy between economic resilience and tourism development is vital for the transformation of China's tourism industry, enhancing its capacity to withstand significant external shocks, and ultimately bolstering its crisis management capabilities [37]. Furthermore, given the tourism industry's high sensitivity to external conditions, resilience offers a fresh analytical perspective for improving the industry's anti-fragility nature and achieving sustainable development in the tourism sector. Tourism economic resilience represents the specific application of resilience within the context of the tourism economy while also benefiting from the achievements of research on regional economic resilience by taking an evolutionary perspective [38]. This concept refers to the capacity of tourism economic systems to restore themselves to their original or preferable condition following a disturbance, thereby enhancing the ability to construct the destination system and facilitating its recovery to a desirable state after an unanticipated incident [39,40].

The COVID-19 pandemic has indisputably demonstrated the inherent vulnerability of the tourism industry. The implementation of various restrictive measures significantly impeded people's daily lives and travel, and it adversely affected tourism activities [41]. Hindrances in consumer behaviour can significantly impact the operation of the real economy. In response to this challenge, certain businesses have been compelled to alter their operational strategies to mitigate the risks associated with the epidemic [42]. Additionally, some hotels or guesthouses, faced with low occupancy and attendance rates, have been left with no choice but to opt for closure

or a shutdown [43]. Transportation methods, such as high-speed rail and airplanes, which play a crucial role in facilitating tourism activities, have intermittently suspended their operations to mitigate the risk of pandemic transmission and to realize containment [44]. Simultaneously, individuals' emotional states have also been impacted within this context, resulting in heightened levels of stress and exerting an influence on their behavioural patterns [45]. Through a retrospective analysis of significant historical events, including major infectious disease outbreaks, natural disasters, and socio-economic crises such as the severe acute respiratory syndrome (SARS) outbreak in 2003, the global financial crisis in 2008, and the COVID-19 pandemic in 2019, it becomes evident that these events, sharing certain similarities, have had a profound and enduring impact on the tourism industry [46,47]. During the pandemic phase, it becomes crucial to facilitate the rapid adaptation and recovery of the tourism business in an environment where both subjective and objective factors are hostile to its development [48]. Hence, the introduction of the notion of "resilience" within this framework seeks to enhance the capacity of the tourism sector to endure, assimilate, adjust, and evolve in times of crisis, thereby mitigating adverse consequences and expediting the process of recovery [49]. The literature on the tourism sector has increasingly emphasized the concept of resilience, with a growing number of researchers acknowledging its benefits and significance in this field. Resilience goes beyond the mere restoration of the original state after a disruption; it involves a dynamic process of adaptation and restructuring to establish a new equilibrium that aligns with the demands of the changed environment [29]. This process of adaptation and transformation has the potential to bring substantial changes in the overall functioning of a business [50]. Existing research on tourism economic resilience is mainly focused on the following perspectives: the examination of resilience in the context of climate change [5]; the exploration of the vulnerability and resilience of enterprises and organizations in the context of disruptions [51]; the investigation of resilience in employment and labour force dynamics [52]; and the resilience of employment and the labour force in tourism destinations [53]. However, in the evaluation of tourism economic resilience, there is a relative lack of assessment from the network structure perspective. Neglecting to consider the impact of risk shocks on important nodes within the network can result in cascading failures throughout the entire network, triggering a series of chain reactions [54].

In the field of research methods, international scholars commonly employ various approaches to measure the resilience of the tourism economy. These approaches include the background trend line method [55], integrated analysis method [56], constructing resilience model, and resilience model [57]20, [58]. Overall, mainstream assessment methodologies for tourism economic resilience may be divided into two approaches: the establishment of core variables and the establishment of indicator systems. The primary goal of developing core variables is to assess tourism economic resilience using measures such as the number of tourists, tourism revenue, and tourism employment (Cartier and Taylor, 2020, [59,60]. In comparison, the latter approach is currently more commonly used. When developing an indicator system, tourism economic resilience is viewed as a term that encompasses dynamic evolution and complicated adaptability. It comprises various dimensions, such as risk resilience, adaptive remodelling capacity, recovery capacity, and path renewal capacity [61]. For example, Martin conducted a seminal study wherein economic resilience was assessed across four dimensions, namely, resilience, organizational capacity, and remodelling capacity (Martin, 2012). Some Chinese scholars have developed a comprehensive indicator system comprising multiple dimensions, including resistance capacity, recovery capacity, adaptability, and restructuring capacity, as well as resistance sensitivity and vulnerability, or resistance and recovery capacity, adaptability and adjustment capability, innovation and transformation ability [62–64]. Previous studies on the measurement of tourism economic resilience using the method of constructing a multidimensional indicator system have laid a strong theoretical foundation for the indicator framework chosen in this study. The subsequent section on the construction and selection of the indicator system provides a comprehensive description of the relevant background and rationale.

Furthermore, the economic resilience of tourism in various regions can be influenced by a multitude of factors [65]. The investigation of the factors that contribute to the economic resilience of tourism in the face of external shocks has also received significant attention in academic research. In post-disaster tourism economic reconstruction studies, researchers have identified 13 key factors that have a significant impact on the process. These factors include the natural environment, financial capital, government policy, and the approach to economic development [66]. The interplay between a destination's image, local policies, and marketing strategies collectively influences the limitations on the destination's resilience [67]. It is apparent that the investigation of tourism economic resilience has emerged as a vital complement to existing studies on regional crisis response [68]. Moreover, it suggests that such research will play a pivotal role in the efforts of the tourism industry to stimulate Chinese tourism demand and foster economic growth.

There is currently little research in China on the resilience of the tourism business in the face of the COVID-19 pandemic. Instead, the emphasis has been on researching COVID-19 prevention and control measures and their implications for the tourism industry [69]. According to several studies, the tourism industry is essential for maintaining economic stability [70]. The Chinese tourism industry suffered a severe contraction once the pandemic broke out, having an impact on a number of factors including overall employment, economic output, and tax receipts. The swift and explosive revival of the Chinese tourism sector following the relaxation of COVID-19 control rules serves as another key test of the industry's resiliency. Based on the literature review, this research assesses the tourism economy's resilience in terms of three stages, namely, risk resistance, recovery, and renewal and restructuring, as well as the rationality of the network structure. By conducting a comparative analysis of the stable period, the pre-shock period, and the shock period, this study seeks to bolster the findings of research on the recovery of Chinese tourism during the COVID-19 pandemic. In addition, it aims to provide relevant recommendations and guidance to the industry.

3. Methodology and data

3.1. The construction of the indicator system

The tourism industry is a multifaceted system, and it is insufficient to rely on a single indicator to fully represent the various characteristics that contribute to the resilience of this economy. The intricate interplay between internal and environmental influences

calls for a more holistic approach. Therefore, to comprehensively assess tourism economic resilience, we have devised a sophisticated framework. This framework incorporates four level 1 indicators, fifteen level 2 indicators, and twenty-five level 3 indicators. The construction of this indicator system is built upon previous research and guided by the adaptability cycle model [71,72]. Specifically, the measurement of tourism economic resilience is primarily conducted from the following perspectives: Risk preparedness ability, Restoration ability, Reorganization, and modernization ability (Martin, 2012), and Rationality of network structure.

(1) Risk preparedness capacity: It is stressed as having the ability to retain one's own structure and capabilities in the face of risky shocks and to fend off interference from other forces [73]. The number of A-class tourist attractions and the number of performances by artistic performing groups are chosen in this study to characterize the richness of tourism resources [74,75]. The tourism economic income, the total number of tourists received, and the number of inbound tourists are chosen to characterize the level of development of the tourism economy [76].
(2) Restoration capability: This feature emphasizes the capacity for self-healing following an impact [77]. The number of travel agencies, star-rated hotels, and public transportation owned by 10,000 people are chosen to characterize the local tourism infrastructure conditions in this paper. The greening coverage rate and sulfur dioxide emission rate are chosen to characterize the environmental conditions [78,79], and the comprehensive utilization rate of solid waste and centralized sewage treatment rate are chosen to characterize the conditions of the ecological environment.
(3) Reorganization and modernization capacity: The primary focus of this capability is predominantly on the process of recombination following adaptation, which results in the development of a novel system characterized by a new state of equilibrium [80]. Fixed asset investment and the actual utilization of foreign capital have been chosen as indicators to assess the level of capital support for the reconstruction of the tourism economy. The number of 10,000 students enrolled in higher education and the presence of tourism management programs in colleges and universities (expressed as a percentage of the total number of colleges and universities owned by prefectural-level municipalities) are used to gauge the availability of skilled tourism professionals [63]. Additionally, internal expenditure on research (R&D) and the number of individuals employed in the tourism industry are used to evaluate the state of innovative technology and labor conditions, respectively.
(4) Rationality of network structure: The rationality of the network structure is evaluated using social network analysis, which starts from the abstract concept of urban networks and proceeds to analyse and assess the relationships between nodes and the composition of the network [81]. Various indicators are employed for this evaluation: Degree Centrality: This metric represents the degree of closeness between nodes and the significance of each node in the network. Betweenness Centrality: It indicates the capacity of a node to control the flow of information within the network. Degree correlation: This measure quantifies the heterogeneity of the network structure. Shortest Path Length: It reflects the overall network's ability to transmit information efficiently. Local Clustering Coefficient: This metric illustrates the degree of network clustering for each node [82].

3.2. Construction of tourism flow network

This article adopts the modified gravity model to measure the level of tourism economic flow, drawing on the research findings of Wang Jun [83] , the calculation formula for this method is as follows:

$$Y_{ij} = K_{ij}\frac{\sqrt{P_i * G_i} * \sqrt{P_j * G_j}}{D_{ij}^2} \tag{1}$$

$$K_{ij} = \frac{R_i}{R_i + R_j} \tag{2}$$

In formulas (1)and (2), D_{ij} represents the minimum distance between two cities; P_i, P_j corresponds to the number of tourists received in each city; G_i, G_j represents the total revenue generated by tourism in each city; K_{ij} denotes the gravitational coefficient; and R_i, R_j reflects the relative richness of natural resources in the respective cities.

3.3. Calculation of rationality of network structure

By utilizing the advanced Ucient software and applying rigorous social network analysis methodologies, we evaluated the network structure using five key indicators: centrality degree, intermediary degree, degree correlation, shortest path length, and local clustering coefficient. The purpose of this analysis was to assess the rationality of the network structure and provide valuable insights into its underlying mechanisms.

3.4. Kernel density estimation

Kernel density estimation is a powerful non-parametric statistical method that has the advantage of avoiding errors associated with the manual specification of functional forms and instead provides an optimal fit to the data. To calculate the kernel density estimate, we use the following formula:

$$f(x) = \frac{1}{nh}\sum_{i=1}^{n} k\left(\frac{x_i - x}{h}\right) \tag{3}$$

In formula(3), $k\left(\frac{x_i-x}{h}\right)$ represents the Gaussian kernel function, while x_i corresponds to the observed values. X denotes the mean of the observed values, n represents the total number of observed values, and h represents the bandwidth.

3.5. Spatial autocorrelation analysis

The utilization of statistical techniques for evaluating the spatial correlation between variables plays a crucial role in comprehending spatial patterns. The assessment of spatial correlation in variables is significantly influenced by the utilization of global and local spatial autocorrelation coefficients. The global Moran's index and the local Moran's index are commonly employed to examine the distribution and clustering of variables at a global scale and the spatial correlation of neighboring units within localized regions, respectively. These indices also play a crucial role in the identification of hotspots and other spatial patterns.

3.6. Geographically and temporally weighted regression model

Expanding on the geographically weighted regression model, we introduce temporal factors to construct a spatiotemporal geographically weighted regression model that captures both temporal and spatial effects. By incorporating both temporal and spatial variables, this approach enables a more comprehensive and nuanced analysis of the data, which in turn leads to a deeper understanding of the complex relationships at play. The specific mathematical formula for this model is outlined below:

$$y_1 = \beta_0\left(u_i, v_i, t_i\right) + \sum_{k=1}^{p} \beta_k\left(u_i, v_i, t_i\right) x_{ik} + \varepsilon_i \tag{4}$$

In formula (4), $\beta_0(u_i,v_i,t_i)$ represents the regression constant of point i; $\beta_k(u_i,v_i,t_i)$ represents the k-th regression coefficient of point i; U_i, V_i represents the centroid coordinates in latitude and longitude; x_{ik} represents the value at point i; and ϵ_i represents the residual.

3.7. Study area and data sources

The area under investigation in this study is the Chengdu-Chongqing (Chengyu) region, renowned for its extensive historical significance, cultural legacy, and plentiful natural and cultural tourism assets. This region encompasses a multitude of internationally acclaimed UNESCO World Heritage sites and highly regarded scenic locations, including but not limited to the Wulong Karst Landscape, Jiuzhaigou Valley, Huanglong Scenic Area, Leshan Giant Buddha, and Sanxingdui Archaeological Site. Based on pertinent data, the tourism revenue in this region exhibited a consistent annual growth rate ranging from 15.8 % to 25.6 % during the period from 2015 to 2019. Notably, this revenue constituted a significant portion, surpassing 20 %, of the region's annual Gross Domestic Product (GDP). Based on the accessible statistics, it is apparent that the tourism industry plays a pivotal role in the economic advancement of the region.

Following the onset of the COVID-19 pandemic, we shall consider Chongqing as an illustrative case. During the initial quarter of 2020, the realized aggregate tourism revenue constituted a mere 21.47 % of the initially projected income. The cultural and tourism enterprises incurred direct economic losses amounting to 2.01 million RMB, while associated industries such as tourism and transportation witnessed a decline in revenue of 66.3 % compared to the previous year. Sichuan Province incurred a substantial economic setback in the tourism sector, amounting to an estimated loss of 60 billion RMB during the Spring Festival of 2020. Numerous travel agencies, hotels, and restaurants of smaller and medium scales, characterized by limited financial resources, faced the imminent threat of closure and financial insolvency.

The significant repercussions of the COVID-19 pandemic on the tourism economy within the Chengdu-Chongqing city cluster underscore the need for research on tourism economic resilience. Such research is crucial for accelerating the recovery of the tourism economy and fortifying preventive measures. As a result, this paper will concentrate on the Chengdu-Chongqing city cluster as a representative region for in-depth research. This urban agglomeration includes a total of 16 cities, comprising Chongqing Municipality and cities in Sichuan Province, such as Chengdu, Zigong, Luzhou, Deyang, Mianyang, and more. The cumulative extent spans an area of 185,000 square kilometers. The primary sources of specific data utilized in this study include the “Chongqing Statistical Yearbook,” “Sichuan Statistical Yearbook,” “China Urban Statistical Yearbook,” “Chongqing Tourism Industry Statistical Bulletin,” as well as various government-published materials such as statistical yearbooks, economic bulletins, and tourism development reports from local municipalities.

4. Results

4.1. The temporal evolution characteristics of tourism economic resilience

4.1.1. Descriptive statistics results

Table 2 and Fig. 1 present the dynamic attributes of tourism economic resilience during the stabilization and shock periods, respectively (see Table 1). Based on the analysis, the following conclusions can be drawn: From a systemic standpoint, the coefficient of variation exhibits an early increase followed by a subsequent drop during the course of the research period. Amidst the repercussions of the pandemic, there has been a decrease of 0.0297 in the coefficient of variation. This suggests a minor decline in the overall spatial disparity of tourism economic resilience within the Chengdu-Chongqing urban agglomeration. The standard deviation exhibits a marginal increment of 0.0181, signifying a little rise in the dispersion. This implies a heightened level of volatility and uncertainty in response to the impact of the pandemic. The Moran's Index demonstrates a geographical positive correlation of low magnitude, accompanied by a somewhat intensified clustering pattern. Fig. 1 illustrates the precise fluctuations in the resilience values of multiple cities

Table 1
Comprehensive evaluation index system for the tourism economy's resilience.

System	Subsystem	Evaluation indicators	Index	Attributes	unit	Indicator Definition
Tourism Economic Resilience	Risk preparedness capability	Number of A-level tourist attractions	x1	+	pcs	The richness of tourism resources
		Number of performances by performing arts groups	x2	+	freq	
		tourism economic income	x3	+	10000RMB	Tourism economic development index
		The total number of visitors received	x4	+	PP	
		Inbound tourist arrivals	x5	+	PP	
		GDP per capita	x6	+	RMB	Economic Base Index
		per capita disposable income of residents	x7	+	RMB	
	Restoration capability	Number of travel agencies	x8	+	pcs	Tourism infrastructure conditions
		Number of star-rated hotels	x9	+	pcs	
		Per 10,000 population, the number of public transportation	x10	+	U	
		Green coverage rate	x11	+	%	Ecological environment conditions
		Sulfur dioxide emissions	x12	–	ton	
		The comprehensive utilization rate of solid waste	x13	+	%	Capacity for pollution abatement
		Centralized wastewater treatment rate	x14	+	%	
	Reorganization and modernization capacity	Fixed Asset Investment	x15	+	10000RMB	Capacity for tourism economic reconfiguration
		Actual Utilized Foreign Investment	x16	+	10000RMB	
		Number of higher education students per 10,000 population	x17	+	PP	Tourism talent pool
		The situation of Tourism Management Programs in Higher Education Institutions	x18	+	pcs	
		Internal R&D expenditure	x19	+	10000RMB	Technical support
		Number of employed persons in tourism	x20	+	PP	Labor conditions
	The rationality of network structure	Degree centrality	x21	+		Degree of connectivity
		Betweenness centrality	x22	+		Ability to control
		Degree correlation	x23	–		Heterozygosity
		Shortest path length	x24	–		Transmission capacity
		Local clustering coefficient	x25	+		Clusterization

Table 2
Descriptive statistics table of resilience in tourism economy.

	Coefficient of variation			Standard deviation			Moran's I		
	2018	2019	2020	2018	2019	2020	2018	2019	2020
	Stable period	Pre-shock period	Shock period	Stable period	Pre-shock period	Shock period	Stable period	Pre-shock period	Shock period
Risk preparedness capability	0.9550	1.4114	1.2353	0.1837	0.2193	0.2064	0.0373	0.0354	0.0281
Restoration capability	0.5394	0.5933	0.5936	0.1594	0.1728	0.1797	−0.0543	−0.0149	0.0021
Reorganization and modernization capacity	1.6297	1.5854	1.3904	0.2373	0.2402	0.2621	0.0087	0.0165	0.0228
The rationality of network structure	0.3562	0.1951	0.3475	0.1924	0.1158	0.1719	0.1283	−0.2366	−0.2097
Tourism economic resilience	0.6882	0.7771	0.7474	0.1673	0.1823	0.1854	0.0049	0.0142	0.0368

at the prefecture level. Chongqing and Chengdu exhibit notable prominence as exemplars of “resilience peaks” and manifest a substantial disparity in comparison to other cities within the region. The city of Chengdu exhibited notable fluctuations in its economic performance from 2018 to 2020, suggesting a heightened susceptibility to the influence of the pandemic. In contrast, Chongqing maintained consistent growth throughout this timeframe. Moreover, several urban areas, namely Meishan, Leshan, Yibin, Nanchong, and Guangan, exhibit a pattern of oscillating expansion. The regression analysis reveals that various economic indicators, such as per capita GDP and disposable income of residents, as well as innovation indicators like the number of university students per 10,000 people and R&D expenditure, have exhibited positive advancements. These improvements have collectively contributed to an overall enhancement in resilience. There has been a notable enhancement in both the recovery capacity and restructuring competence. Several cities, including Mianyang, Deyang, and Ziyang, have a pattern characterized by fluctuating declines. The indicators analysis demonstrates a considerable decline in tourism-related variables, such as the number of artistic performances, tourist earnings, and visitor numbers. Moreover, there is a notable decrease in fixed asset investment and the level of tangible foreign capital utilization, indicating a dip in financial inputs. These aforementioned elements have thus resulted in a notable fall in the propensity to withstand risk and the ability to adapt and reorganize, thereby leading to an overall decline in resilience.

At the subsystem level, there is an observed changing trend in the growth of the coefficient of variation, standard deviation, and Moran's Index of risk resistance capacity from 2018 to 2019, followed by a subsequent reduction from 2019 to 2020. Specifically,

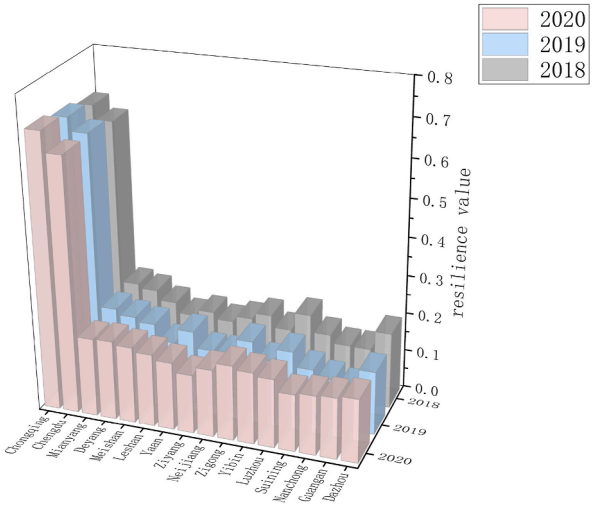

Fig. 1. The temporal evolution graph of resilience in the tourism economy.

there were decreases of 0.1761, 0.0129, and 0.0037 in these measures, respectively. The results indicate that in response to the pandemic impact, the spatial disparity in risk resistance capacity has narrowed, and the dispersion has decreased, showing a weak overall spatial correlation. On the contrary, the restoration capability as a whole demonstrates a consistent and positive trajectory over the duration of the study. This can be attributed to the resilience of urban infrastructure and greening facilities, which are relatively less impacted or exhibit delayed impacts, thereby contributing to the overall stability of the restoration capacity. The observed rise in the coefficient of variation, standard deviation, and Moran's Index by 0.0542, 0.0203, and 0.0564, respectively, indicates that there has been a persistent escalation in spatial inequality and dispersion of recovery ability in response to the effects of the pandemic. Furthermore, a shift has occurred from a negative to a positive spatial correlation, indicating a heightened clustering characteristic. In relation to the reorganization and modernization capacity, there has been a decline of 0.2393 in the coefficient of variation, accompanied by an increase of 0.0248 in the standard deviation. Additionally, Moran's Index has shown an increase of 0.014. The results indicate that the ability to restructure in different geographic areas has been affected by the pandemic, resulting in a notable decrease in spatial disparity. However, there has been a modest increase in dispersion. While a positive spatial correlation can be observed, the overall trend in spatial correlation is quite modest. The network structure's rationality demonstrates a pattern of initial drop followed by a subsequent increase, displaying fluctuations over time. The coefficient of variation exhibits an increase of 0.1524, the standard deviation demonstrates an increase of 0.0561, and the Moran's Index displays an increase of 0.0269. This implies that the rationality of the network structure's spatial disparity and dispersion has experienced fluctuations and an overall increase as a result of the impact of the epidemic. Chengdu and Chongqing, being designated as “dual-core” cities, exhibit distinct benefits in terms of their control capability, interconnection, and agglomeration. Following the impact on the core cities, a cascade of interconnected events ensues, resulting in the disconnection and loss of control in other non-core nodes. This situation, to a certain degree, further exacerbates the existing regional difference.

4.1.2. Kernel density estimation results

To gain a more thorough comprehension of the temporal dynamics of tourism economic resilience in the Chengdu-Chongqing urban agglomeration, we conducted kernel density estimation on the resilience values spanning the years 2018–2020, as depicted in Fig. 2. The kernel density curve for the period of 2019–2020 exhibited a rightward movement, accompanied by a discernible decrease in the leftmost area. This change indicates a progressive enhancement in the overall robustness of the tourism economy. In the year 2018, a notable occurrence of a distinct “sharp peak” was documented, which then transitioned into a more gradual “gentle peak” in the following year 2019. However, this trend reverted again to a “sharp peak” in the year 2020. This observation suggests that there is a notable differential among prefecture-level cities, and the regional gap exhibits a pattern of fluctuation characterized by periods of shrinking followed by periods of widening, which aligns with the aforementioned analysis findings. The substantial disparity in elevation between the primary summit and the secondary summit exemplifies a pronounced spatial heterogeneity.

4.2. Spatial evolution characteristics of tourism economic resilience

4.2.1. 1Spatial differentiation pattern

According to the natural breakpoint method, the tourism economic resilience pattern of the Chengdu-Chongqing urban agglomeration in the years 2019 and 2020 will be categorized into five distinct areas: I representing the low resilience area, II representing the relatively low resilience area, III representing the moderate resilience area, IV representing the relatively high resilience area, and V representing the high resilience area, as depicted in Fig. 3. The findings indicate that: ①; In 2018, the first-level regions included NanChong and GuangAn. The second-level regions included LeShan, YiBin, SuiNing, and ZiYang. The third-level regions included YaAn, MeiShan, NeiJiang, ZiGong, and DaZhou. The fourth-level regions included MianYang, DeYang, and LuZhou. The fifth-level regions

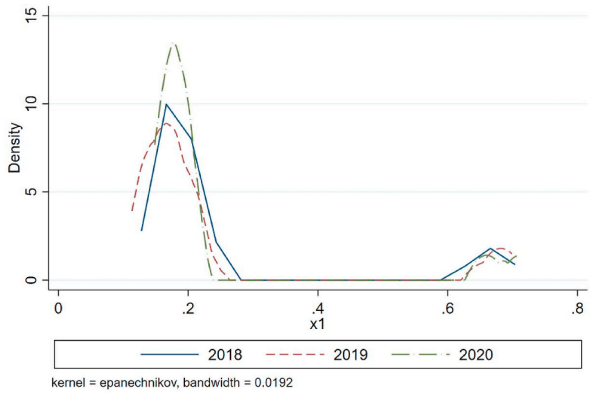

Fig. 2. The kernel density estimation plot.

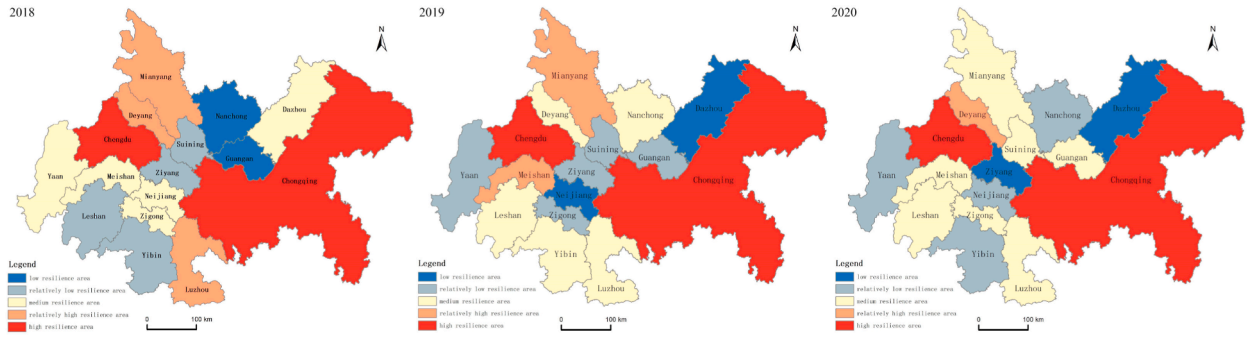

Fig. 3. The spatial evolution map of resilience in the tourism economy.

included Chengdu and Chongqing. ②; In 2019, several cities underwent notable alterations in their regional categories as compared to the preceding year of 2018. The regions of NeiJiang and DaZhou underwent a transition from being classified as third-level regions to being classified as first-level regions. The administrative regions of YaAn and ZiGong underwent a transition from the third-level to the second level. The regions of LuZhou and DeYang underwent a transition from the fourth-level to the third-level classification. The administrative classification of NanChong was modified from a first-level region to a third-level region. The region of GuangAn underwent a transition from a first-level administrative division to a second-level administrative division. YiBin and LeShan underwent a transition from a second-level administrative division to a third-level administrative division. MeiShan underwent a transition from a third-level administrative division to a fourth-level administrative area. ③; In 2020, there were alterations seen in regional categories for specific cities as compared to the year 2019. YiBin and NanChong underwent a transition from being classified as third-level regions to being classified as second-level regions. ZiGong, GuangAn, and SuiNing underwent a transition from being classified as second-level regions to being categorized as third-level regions. The regions of MeiShan and MianYang underwent a transition from the fourth level to the third level. DeYang underwent a transition from a third-level administrative division to a fourth-level administrative division. ZiYang transitioned from a second-level administrative division to a first-level administrative area. The administrative classification of NeiJiang was modified from a first-level region to a second-level region.

Generally speaking, during the research period, it was observed that the Chengdu-Chongqing urban agglomeration had a very limited number of fourth-level and fifth-level regions. These regions were primarily concentrated in the eastern portion of Chongqing and the western half of Chengdu, including its metropolitan area. The regions at the third level exhibited the greatest proportion and demonstrated a generally consistent spatial distribution. The findings indicate that the tourism economic resilience of the Chengdu-Chongqing urban agglomeration is rather strong, while there are notable variations in this region. The primary and secondary regions are primarily concentrated in the central portion of the Chengdu-Chongqing region, as well as in locations such as Dazhou in the northeastern province of Sichuan. The spatial distribution of tourism economic resilience has distinct wings on either side, a central depression, and an even distribution between the northern and southern regions.

4.2.2. Spatial evolution type

Based on the analysis of the evolution of tourism economic resilience in prefecture-level cities between 2019 and 2020, it is possible to categorize them into four distinct stable types: low-level stable, relatively low-level stable, moderate-level stable, relatively high-level stable, and high-level stable. Additionally, three types of declining cities can be identified: mildly declining, moderately declining, and severely declining. Lastly, three types of growing cities can be observed: mildly growing, moderately growing, and highly growing, as depicted in Fig. 4.

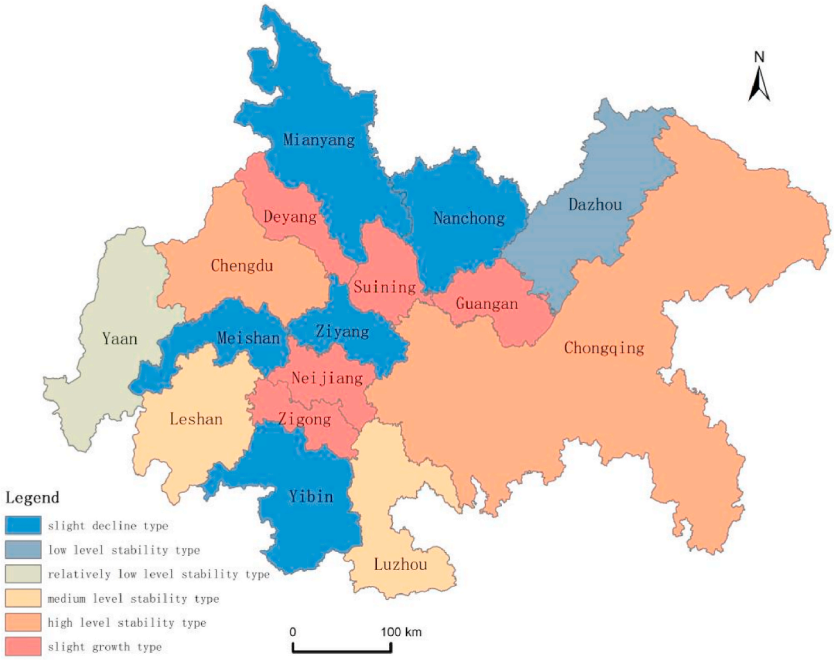

Fig. 4. The Evolution Types Chart of Resilience in the Tourism Economy (systemic level).

At the systemic level, the category characterized by moderate-to-low levels of stability encompasses Dazhou, while the relatively low-level stable category comprises Ya'an. The moderate-level stable category encompasses Leshan and Luzhou, whereas the high-level stable category includes Chengdu and Chongqing. The category of mildly growing cities encompasses Neijiang, Zigong, Deyang, Suining, and Guangan. The category of declining regions encompasses several municipalities, namely Yibin, Meishan, Ziyang, Mianyang, and Nanchong, which can be classified as mildly declining.

In light of the repercussions of the COVID-19 pandemic, the Chengdu-Chongqing urban agglomeration's tourism economic resilience is primarily characterized by three distinct patterns: multi-level stability, slight growth, and slight decline. Chengdu and Chongqing, as high-value areas, have maintained stable resilience throughout the period. The center region is divided into two portions by the city of Ziyang, which forms a connecting "T" shaped growth area between Chengdu and Chongqing. Indicator analysis revealed that in 2020, Ziyang experienced a sharp decline in the number of inbound tourists and the number of artistic performances by performing groups, leading to a rapid decrease in its risk resistance capacity. The sharp decline in the number of tourism practitioners severed the ability to generate tourism revenue in Ziyang, affecting its ability to resist risks.

From the perspective of subsystems, as shown in Fig. 5.

(a) Risk preparedness capability: Dazhou and Ziyang show a low-level stable type. SuiNing, GuangAn, and NeiJiang demonstrate a relatively low-level stable type. YaAn, ZiGong, and LuZhou exhibit a medium-level stable type. YiBin and LeShan fall into the high-level stable type. Chengdu and Chongqing represent the slight growth type. Overall, the risk preparedness capability shows a stable trend with slight growth in some cities.

(b) Restoration capability: Dazhou, YaAn, and NeiJiang are categorized as the low-level stable type. MianYang, MeiShan, and ZiGong belong to the high-level stable type. Chengdu and Chongqing demonstrate a slight growth type. South cities such as YiBin, GuangAn, and Suining fall into the moderate growth type. The overall restoration capability remains stable, with only three cities showing a declining trend.

(c) Reorganization and modernization capacity: Ziyang, Suining, and GuangAn are classified as the low-level stable type. MeiShan, YiBin, and Dazhou are placed in the relatively low-level stable type. NeiJiang and ZiGong exhibit a medium-level stable type. MianYang, DeYang, and YaAn demonstrate the high-level stable type. Chengdu and Chongqing represent the slight growth type, while LeShan and NanChong exhibit the moderate decline type. Overall, the reorganization and modernization capacity remain stable, with some cities showing slight changes.

(d) Rationality of network structure: YaAn falls into the low-level stable type. Dazhou, MianYang, Chengdu, and YiBin belong to the relatively low-level stable type. NeiJiang represents the medium-level stable type. Chongqing, GuangAn, SuiNing, and LuZhou exhibit a slight growth type. DeYang and ZiGong demonstrate the high-level growth type. LeShan and NanChong fall into the moderate decline type. MeiShan and Ziyang represent the significant decline type. Overall, the rationality of network structure shows a significant fluctuating trend, with Chongqing metropolitan area cities showing significant growth, while Chengdu metropolitan area northern and western cities remain relatively stable, and southern cities exhibit significant changes.

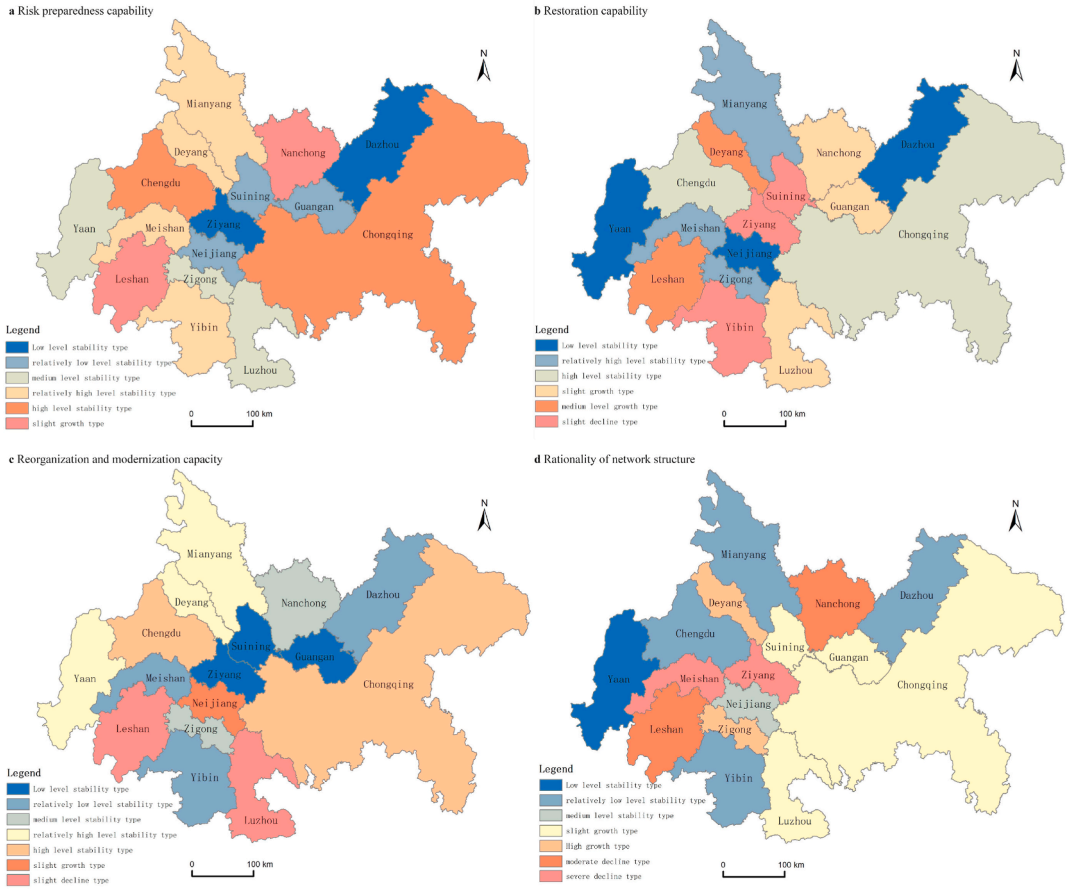

Fig. 5. The Evolution Types Chart of Resilience in the Tourism economy (subsystems level).

4.3. Analysis of factors affecting the resilience of the tourism economy

4.3.1. Selection and explanation of influencing factors

The resilience of the tourism economy is influenced by a multitude of factors. This article conducts a thorough examination of the extant literature to ascertain the primary determinants that impact the resilience of tourism from five distinct viewpoints: economic development level, tourism talent reserve situation, infrastructure conditions, ecological environment conditions, and level of openness to foreign markets. The selected indicators for each perspective are presented in Table 3. The proportion of the tertiary industry in the Gross Domestic Product (GDP) serves as an indicator of the region's economic development stage and overall level. Similarly, the number of higher education institutions can be seen as a measure of the availability of skilled personnel in the tourism sector. The length of highways can provide insights into the region's infrastructure conditions and connectivity. Additionally, the annual average PM2.5 content can be used to assess the ecological environment conditions. Lastly, the volume of imports and exports can be indicative of the region's level of openness to international trade.

4.3.2. The comparison of models and collinearity test

Table 4 presents the results of the multicollinearity test, which showed strong collinearity between the number of higher education institutions (β) and the volume of imports and exports (ε), with a VIF value > 10. As a result, these variables were excluded, and the study retained three variables: the proportion of the tertiary industry in GDP (α), the length of highways (γ), and the annual average PM2.5 content (δ).

Table 3
Selection and explanation of influencing factors.

Variable name	symbol	Variable meaning
The proportion of the tertiary sector in the GDP	α	level of economic development
the number of tertiary education institutions	β	tourism talent reserve situation
the length of highways	γ	infrastructure conditions
The annual average concentration of PM2.5	δ	ecological environment conditions
the volume of import and export trade	ε	level of openness to foreign markets

Table 4
Multicollinearity test.

	α	β	γ	δ	ε
2018 (VIF)	3.875	72.005	4.7	1.098	67.997
2019 (VIF)	3.012	43.443	4.364	1.211	37.056
2020 (VIF)	3.411	35.105	4.287	1.294	44.975

To evaluate and compare the goodness of fit of the OLS, GWR, and GTWR models, we conducted regression analyses. As shown in Table 5, the AICc value of the GTWR model was found to be the smallest, followed by the GWR model and the OLS model. Furthermore, the GTWR model exhibited higher R^2 and Adjusted R^2 values compared to the GWR and OLS models, indicating that it provides a better explanation of the relationship between independent variables and the resilience of the tourism economy in terms of spatiotemporal effects.

4.3.3. Results of GTWR model analysis

Economic factors: Based on the findings presented in Fig. 6 (α), it is evident that the impact of economic factors on the tourism economic resilience of the Chengdu-Chongqing urban agglomeration exhibits a significant level of spatial heterogeneity. The regions of Suining and Ya'an exhibit the most pronounced adverse inhibitory impact, necessitating further optimization of the industrial structure to expedite the transition from traditional to modern sources of energy. The cities of Neijiang, Yibin, and Chongqing exhibit a marginal negative hindering effect and a marginal positive driving effect, respectively. The indicators analysis reveals that the proportion of the tertiary industry in Yibin consistently remains at a low level and exhibits slow growth. In contrast, the proportion of the tertiary industry in Neijiang and Chongqing is already at a medium-high level, but experiences slow growth and fluctuates during the study period. Consequently, these findings indicate a negative effect in the case of Yibin and a weak positive effect in the case of Chongqing. The cities of Chengdu, Ziyang, Mianyang, Nanchong, and Dazhou can be classified into two clusters characterized by moderate positive drivers. On the other hand, Zigong, Guang'an, Deyang, Meishan, Leshan, and Luzhou exhibit the most pronounced positive drivers, primarily due to the diffusion effect originating from the dual-core cities. In general, the regional patterns of the impact of economic factors on the resilience of the tourism industry in the Chengdu-Chongqing urban agglomeration can be summarized as follows: The northern regions demonstrate a notable positive driving influence, whilst the southern regions display notable fluctuations in their reactions. Furthermore, it is worth noting that there exists a significant core-periphery impact inside the Chengdu metropolitan area.

Infrastructure factors: Based on the data presented in Fig. 6 (γ) , it is evident that infrastructure factors pose the most significant hindrance to the development of Ya'an, Deyang, and Suining. These cities are primarily situated in the peripheral regions of the Chengdu metropolitan area. The presence of a high population density and a concentration of economic activities can result in transportation inefficiencies and increased commuting time, thereby impeding mobility and overall efficiency. Additionally, certain regions may experience inadequate road connectivity due to factors such as topography, resource allocation, or insufficient investment. This could potentially impact the overall experience and accessibility for travelers. The cities of Neijiang, Yibin, and Chongqing exhibit a modest negative hindering effect and a modest positive driving effect. The cities of Chengdu, Ziyang, Zigong, and Nanchong

Table 5
The goodness of fit comparison.

	2018		2019		2020		2018–2020
	OLS	GWR	OLS	GWR	OLS	GWR	GTWR
AICc	−32.9902	−24.9890	−21.6316	−21.6300	−23.0966	−23.0894	−369.4725
R^2	0.8278	0.8280	0.8211	0.8213	0.8421	0.8422	0.9922
Adjusted R^2	0.7228	0.7848	0.7764	0.7765	0.8026	0.8027	0.9916

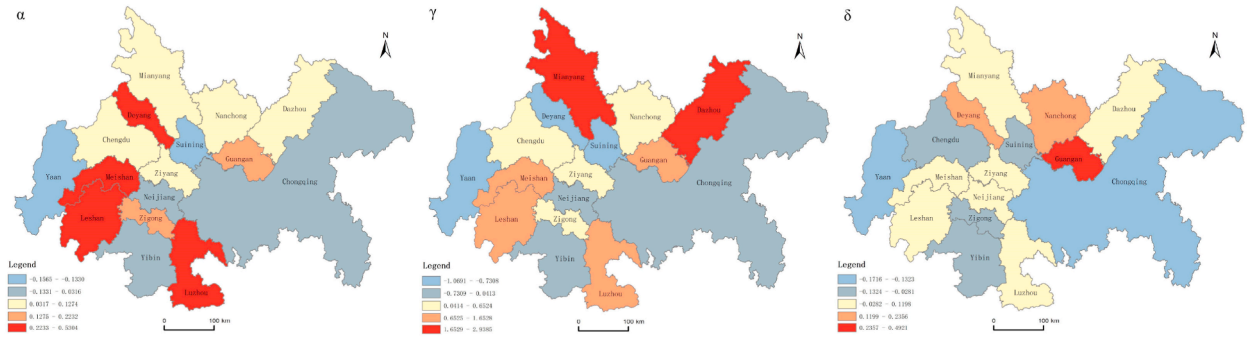

Fig. 6. Spatial heterogeneity of influencing factors.

exhibit a moderate positive driving effect. The positive driving effects of Meishan, Leshan, Luzhou, Mianyang, and Dazhou can be attributed to the benefits derived from tourism cooperation and exchanges with neighboring regions. The presence of efficient transportation connectivity further enhances inter-regional travel for tourists, thereby facilitating the sharing and complementarity of tourism resources. Notably, Mianyang and Dazhou exhibit the most pronounced positive driving effects. In general, the spatial distribution of infrastructure factors can be characterized as follows: the northern regions display a positive driving pattern that resembles the shape of the letter "Y," while the central and western regions exhibit a positive driving pattern resembling the shape of the letter "T." On the other hand, the eastern and central regions demonstrate a scattered distribution with negative impacts.

Ecological environment factors: Based on the analysis of (δ) in Fig. 6, it is evident that the overall driving efficiency of ecological and environmental factors is relatively low. Additionally, the spatial pattern exhibits significant variations, primarily characterized by negative and moderate positive driving forces. The cities of Chengdu, Suining, Zigong, and Yibin display notable negative inhibitory effects, whereas Chongqing and Ya'an exhibit the most pronounced negative inhibitory effects. Deyang, Nanchong, and Guang'an demonstrate significant positive factors that contribute to their overall strength. The majority of the remaining cities exhibit diminished negative inhibitory effects and diminished positive facilitative effects. The influence of ecological environmental factors on the tourism economic resilience of the Chengdu-Chongqing urban agglomeration displays a spatial pattern characterized by significant positive driving effects in the central region, and negative inhibitory effects in the eastern and western regions, resulting in a spatial distribution that can be described as a "collapse".

5. Discussion

Since the turn of the 21st century, tourism has garnered significant recognition as a crucial driver of economic growth. Concurrently, tourism has assumed a pivotal role in the economic development of China [84,85]. Global tourism and its associated industries have been significantly affected by the outbreak of the novel coronavirus in 2020 [86]. Given the extensive impact of COVID-19 in China, the implementation of effective resilience planning and pre-planning measures can mitigate the adverse consequences of the shock and expedite the process of recovery [87]. It is critical to think about how to protect both tourists and those working in the tourism sector when faced with unforeseen catastrophes, such as the COVID-19 pandemic. The long-term effects of such shocks must also be considered, and measures to create a more resilient and sustainable tourism economic system should be taken. The findings of this study hold considerable importance for advancing the advancement of the tourism economy and associated policies in the Chengdu-Chongqing region and on a national scale. The results of this research give rise to the following recommendations: ① It is crucial to narrow the gap in tourism economic resilience between regions and reduce the reliance on core cities. The development of the tourism industry is contingent upon a stable and favourable external economic environment. As the research findings in this paper show, when confronted with shocks, core cities with a high-degree value and extensive interconnectedness can swiftly disseminate negative impacts along their network of connections. For peripheral cities, the over-reliance on spillover benefits from core cities might act as a welfare siphon during stable times but can amplify crises when shocks occur. Hence, while benefiting from the spillover effects of core cities, each city within the region should prioritize independent and autonomous development to enhance its capacity for innovative growth. ② Adapting to local advantages and addressing weaknesses in tourism economic development are of the utmost importance. It is essential to foster unique and distinctive tourism products and services. The analysis results from the GTWR model reveal significant spatial heterogeneity among the three types of influencing factors in the Chengdu-Chongqing urban agglomeration. In the future, each region should proactively address its specific shortcomings and work towards improvement accordingly. Considering the characteristics of the post-pandemic tourism market, adjusting the structure of tourism product supply becomes imperative. This adjustment will play a crucial role in mitigating the lingering impact of the pandemic and facilitating the recovery of the tourism economy. ③ Enhancing the spatial pattern of the tourism system and optimizing functional allocation are paramount. By capitalizing on the national development strategy in the southwest region, establishing a robust tourism backbone will drive comprehensive growth in the tourism economy. Embracing a holistic regional perspective, fostering coordinated development among different points, lines, and areas through unified planning and capitalizing on complementary advantages become imperative.

The primary contribution of this research lies in the introduction of urban network thinking into the development of an evaluation system for assessing the resilience of tourism economies. The enhancement and refinement of the evaluation of tourist economic resilience are achieved by establishing a city connection network and deriving indicators from the network. Furthermore, this study undertakes a cross-sectional analysis to compare the condition of tourism economic resilience in the Chengdu-Chongqing urban agglomeration before and after the onset of the COVID-19 pandemic. This approach offers a clearer understanding of the changing dynamics of tourism economic resilience in response to unexpected disruptions. This study provides a scholarly foundation for the secure and sustainable growth of the tourism sector in the Chengdu-Chongqing urban agglomeration and other comparable regions.

In future investigations, it is imperative to acquire a more comprehensive set of firsthand survey data to enhance the depth and breadth of the research. The current study focuses on prefecture-level cities as the geographical study unit. In the future, research on tourism in the Chengdu-Chongqing region should be further refined to the county-level scale to enhance the accuracy and precision of research. The indicator system method employed in this study to evaluate tourism economic resilience may not fully capture the actual "process-oriented" demonstration of resilience. In future research, other methods can be adopted to compensate for this limitation. In future research on tourism economic resilience, we foresee the following possibilities: We can employ a combination of qualitative and quantitative research methods, including surveys and interviews, to collect primary data. To gain deeper insights, we can focus on the county-level spatial scale, acquiring micro-level tourism resource data within counties, and conduct further investigations into specific enterprises or tourist destinations. Additionally, building on the comparative analysis approach outlined in this paper, especially in the context of external shocks and considering regional variations, and conducting simultaneous comparisons of

tourism economic resilience across multiple city clusters or regions in China will serve as a significant method for uncovering spatial heterogeneity and identifying vulnerable aspects of tourism economic resilience.

6. Conclusion

By analyzing the spatio-temporal evolution and influencing factors in the previous section we find that : Time dimension: In response to the pandemic impact, the overall spatial disparity in tourism economic resilience among cities in the Chengdu-Chongqing urban agglomeration has slightly reduced. Nevertheless, the region now experiences heightened volatility and uncertainty, which is consistent with both kernel density estimation and descriptive statistical analysis. Chongqing and Chengdu, both notable instances of "resilience peaks," exhibit a considerable disparity when compared to other cities in the vicinity. Chengdu, specifically, exhibits a heightened susceptibility to the impact of the epidemic. Several cities, including Mianyang, Deyang, and Ziyang, have experienced a fluctuating decline in tourism economic resilience. The significant reductions in risk resistance and restructuring capacities in these cities have led to an overall decline in resilience across the region.

Spatial dimension: In terms of spatial patterns, the overall tourism economic resilience of the Chengdu-Chongqing urban agglomeration exhibits prominent wings on both sides, a central depression, and a balanced distribution between the north and south. Regarding spatial evolution types, the tourism economic resilience in the Chengdu-Chongqing urban agglomeration is dominated by multi-level stability, mild growth, and slight decline types. The "Chengdu-Chongqing" region maintains consistently high values, with the central area forming a "T" shaped growth zone, divided by an anomalous point - Ziyang. The Chengdu-Chongqing urban agglomeration demonstrates distinct spatial patterns in its overall tourism economic resilience, characterized by strong wings on either side, a core depression, and a balanced distribution between the northern and southern regions. The tourism economic resilience within the Chengdu-Chongqing urban agglomeration is primarily characterized by three forms of spatial evolution: multi-level stability, mild development, and small decline. The "Chengdu-Chongqing" region maintains consistently high values, with the central area forming a "T" shaped growth zone, divided by an anomalous point - Ziyang. Within the subsystem, the stability of risk resistance capacity and restructuring capability is observed, however, more prominent alterations are observed in the recovery capacity and rationality of the network structure.

Influencing factors: In terms of economic aspects, it can be observed that the northern region demonstrates a greater degree of positive momentum, displaying notable disparities in levels when compared to the southern sections. The significance of the core-periphery impact inside the Chengdu urban region is noteworthy. Regarding infrastructure factors, a positive concentration may be observed in the northern and center-western regions, forming a "Y"-shaped and "T"-shaped pattern, respectively. Conversely, the eastern and central areas exhibit a dispersed distribution characterized by negative effects. In relation to ecological environmental elements, it is shown that the central region has a notable positive driving influence, whilst the eastern and western regions demonstrate a substantial negative inhibitory effect.

CRediT authorship contribution statement

Chenhao Ding: Writing - original draft. **Xin Gao:** Funding acquisition, Writing - review & editing. **Zhiyang Xie:** Data curation, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data source has been pointed out in the paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2024.104255.

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