

Dynamic Evolution of Tourism Economic Resilience in the Pearl River Delta, China

¹Xiaoxiao Yi, ²Sutana Boonlua, and ^{3*}Paranee Boonchai

**Corresponding author*

^{1, 3*}Faculty of Tourism and Hotel Management, Mahasarakham University, Thailand

²Mahasarakham Business School, Mahasarakham University, Thailand

E-mail: ¹yixiaoxiao@gxnun.edu.cn, ²sutana.t@acc.msu.ac.th, ^{3*}paranee.b@msu.ac.th

Received August 19, 2025; **Revised** September 21, 2025; **Accepted** October 1, 2025

Abstract

With the rapid growth of global tourism, tourism economic resilience has become a key metric for assessing a region's ability to withstand external shocks and sustain development. Resilience transitions reflect shifts in this capacity over time. This study aimed to examine the spatiotemporal evolution of tourism economic resilience in the Pearl River Delta (PRD), focusing on (1) overall temporal trends, (2) spatial patterns and aggregation, and (3) spatial dynamic transitions. A comprehensive evaluation system, with indicators weighted using the entropy weight method to reduce subjectivity, was developed to measure tourism economic resilience. The study employed kernel density estimation and spatial Markov chain models to analyze temporal changes, spatial distributions, and dynamic transitions from 2003 to 2022. The analysis revealed four development phases, showing overall improvement but persistent polarization in low-resilience areas. Spatially, resilience followed a "strong north, prominent central-southeast, weak periphery" pattern, with limited spillover from core cities. Markov results showed high-resilience cities remained stable, while most transitions occurred among lower-resilience cities, suggesting limitations in traditional spillover assumptions.

Keywords: Spatiotemporal Evolution; Dynamics Evolution; Tourism Economic Resilience

Introduction

As the world's largest domestic tourism market and a key source and destination of international tourism, China plays a vital role in the global tourism economy, exerting an irreplaceable influence on its recovery and development. The COVID-19 pandemic has posed unprecedented challenges to the tourism sector worldwide, severely disrupting travel flows and economic activities (Sharma et al., 2021). This highlights the critical importance of studying tourism economic resilience, particularly in dynamic regions like the Pearl River Delta, which serves as both a crucial domestic tourism hub and a significant international gateway.

The Pearl River Delta (PRD), located in southern China, includes key cities such as Guangzhou, Shenzhen, and Foshan. The region is known for its economic vitality and robust tourism industry (Du et al., 2019). Studying the Pearl River Delta's tourism economy resilience holds both practical significance and academic value, as illustrated in the following aspects: First, the Pearl River Delta's emphasis on sustainable development aligns with China's national vision of "Lucid waters and lush mountains are invaluable assets," providing a clear developmental framework for research on tourism economic resilience (Wang et al., 2022). Theories of sustainable tourism development and resilience thinking underscore the importance of maintaining long-term economic health while adapting to challenges (Adams et al., 2021; Zhang et al., 2022). In this context, resilience theory offers a robust theoretical foundation for understanding how the tourism system in the Pearl River Delta evolves and adapts over time in response to both internal and external shocks, thus making the Pearl River Delta a key case study for exploring the dynamics of resilience. Second, significant economic development disparities within the Pearl River Delta have profound implications for tourism economic resilience (Jiao et al., 2019). These disparities, both spatial—between core cities and peripheral regions—and temporal—over time—directly affect the resilience of individual cities' tourism economies. According to spatial resilience theory, such imbalances can hinder the ability of peripheral regions to recover from economic downturns (Zhang et al., 2022), emphasizing the need for targeted resilience research in these areas.

Overall, understanding the spatiotemporal and dynamic evolution of tourism economic resilience is crucial, as it enables the identification of areas where interventions are most needed. Previous studies have demonstrated that resilience measurement is an effective tool for capturing and quantifying these spatiotemporal changes (Ding & Fan, 2024). However, most existing research has not effectively integrated advanced methods such as kernel density estimation (KDE)

with spatial Markov chain models in the context of tourism resilience. This methodological gap limits the ability to capture both the distributional dynamics and spatial transition mechanisms simultaneously, leaving an important space for further exploration. Third, findings from this study will help national-level urban agglomerations in other Asian countries draw on the experience of the Pearl River Delta to formulate tourism policies tailored to their national contexts, ultimately contributing to development on sustainable tourism resilience in rapidly developing regions (Amul et al., 2022).

Research Objectives

The research objectives of this study are as follows:

1. To investigate the temporal trends and dynamics of tourism economic resilience Within the study period.
2. To examine the temporal and spatial patterns of resilience levels within the tourism economy.
3. To analyze the spatial and dynamic evolution of tourism economic resilience in the Pearl River Delta region.

Literature Review

This section reviews prior studies on tourism economic resilience, exploring its conceptual evolution, spatial-temporal research, while identifying gaps in the economic domain to provide a foundation for this paper's research.

1. Concept of Resilience and Economic Resilience

Resilience evolved from engineering resilience, which focuses on a system's ability to quickly recover from shocks (Holling, 1973), to ecological resilience, which highlights the ability to adapt and absorb disturbances in systems with multiple equilibria (Adger & Vincent, 2005). Model in the ecological area emphasize a form of equilibrium resilience, specifically the ability to restore equilibrium (Reggiani et al., 2001). However, this model are limited for dynamic systems like regional economies (Simmie & Martin, 2010). Evolutionary resilience, focusing on adaptation, transformation, and innovation in response to ongoing changes, offers a more fitting framework for economic systems (Du et al., 2022; Hudson, 2010). Unlike equilibrium-based models, this dynamic perspective views resilience as an ongoing, transformative process, emphasizing adaptability and innovation, with scholars exploring its integration into development strategies and

long-term planning in volatile environments (Hassink, 2010; Hill et al., 2012; Sutton & Arku, 2022). This framework is critical for long-term planning in volatile, global environments.

2. The Temporal and Spatial Evolution of Tourism Economic Resilience

In general, the spatiotemporal evolution of tourism economic resilience refers to the adaptive capacity and processes of the tourism economic system to external shocks and changes across different regions and periods (Wang et al., 2022). Existing Studies have shown that core cities generally exhibit higher resilience than peripheral ones (Du et al., 2019). Research on Chinese provinces also reveals higher resilience in regions like Beijing, Guangdong, and Shanghai, while areas such as Xinjiang and Inner Mongolia rank lower (Wang & Wei, 2021). Regional comparisons also show that the Northeast region has higher resilience than the national average, but larger cities are more vulnerable to shocks (Y. Hu et al., 2022). Similarly, the Western regions exhibit the highest urban resilience, followed by the Central and Northeastern regions, with the Eastern regions showing the lowest (T. Cheng et al., 2022).

In summary, while significant spatial differences in economic resilience have been identified, there is a lack of in-depth analysis regarding the dynamic evolution of this resilience (Huang et al., 2023). Disparities in cities' locational conditions, economic foundations, and policy support lead to distinct tourism economy performances in China (Cai & Xu, 2023). Understanding the spatial variations in urban tourism economic resilience is crucial to addressing these disparities and promoting balanced, sustainable development in tourism economies, making studying its spatiotemporal evolution highly necessary.

3. comprehensive evaluation index of Tourism Economic Resilience

The measurement of tourism economic resilience refers to evaluating the tourism economy's adaptation and recovery characteristics in response to external shocks or changes through quantitative methods (Hu et al., 2021). In terms of measurement methods, Currently, the academic community employs two primary methods to assess the tourism economy resilience: Comprehensive evaluation index system method (Brown & Greenbaum, 2017; Cheng & Zhang, 2020) and Core variable method (Zhang et al., 2022). The core variable method selects a key variable, such as GDP and employment, that is sensitive to economic changes and evaluates the resilience of the economic system based on how this variable responds to external shocks (Martin & Gardiner, 2019). However, economic resilience is a dynamic process that involves multiple stages, including the ability to resist shocks, return to equilibrium, adapt to the environment, and

overcome challenges (Martin, 2012). Therefore, relying on a single indicator like GDP or employment may not comprehensively capture the full extent of a region's economic resilience.

In contrast, the Comprehensive Evaluation Index System method involves selecting multiple indicators that reflect various facets of resilience. These indicators are quantified and combined into a composite score to assess overall resilience. This approach captures the multidimensionality of the tourism economic system, leading to a more scientifically rigorous evaluation of resilience (Zhang et al., 2020). For this reason, this study employs the Comprehensive Evaluation Index System Method to evaluate the resilience of the tourism economy, as it offers a broader and more comprehensive measure of resilience compared to using a single variable.

Regarding the index system, there is still a limited unified evaluation index system for tourism economy resilience systems. Existing dimensions of tourism resilience assessment mainly include stability, sensitivity, adaptability, resistance, recovery, reconstruction, and renewal (Huang et al., 2023). Such assessment primarily considers the evolution process of external emergencies while overlooking the evaluation of the long-term cumulative effects of external emergencies (Huang et al., 2023). This study constructs a tourism economic resilience evaluation index system based on three dimensions: resistance and recovery, adaptation and adjustment, and innovation and transformation. By comprehensively incorporating the impacts of external emergencies and the long-term effects on the system into the evaluation index system, tourism economic resilience measurement accuracy can be enhanced (Zhang et al., 2022) (as shown in Table 1).

Table 1 System of Tourism Economic Resilience Evaluation Index System

Dimension	Criterion layer	Index layer	Descriptive
Resistance and recover	Tourism resources abundance	Tourism resource density	Total number of tourist attractions/area of administrative area (number/ten thousand square kilometres)
		Tourism economic development	Domestic tourism revenue
	International tourism revenue		Foreign exchange earnings from tourism (millions of dollars)
	Proportion of the tourism industry		Gross tourism receipts/GDP (%)
	Local economic development	Per capita consumption expenditure of urban residents	Per capita consumption expenditure of urban residents (Yuan)
		Industrial structure	Herfindahl–Hirschmann Index
		Proportion of tertiary industry	Value added of services/GDP (%)
	Tourist facilities	Road network density	Class road mileage/area of administrative area (km/km ²)
		Total number of travel agencies	Total number of travel agencies (homes)
		Number of star-rated hotels	Reflects the level of tourism reception capacity in the region (homes)
Adaption and adjustment	Human resources	Number of people employed in tourism	Number of employees in accommodation and catering (10,000)
		Number of employees in the tertiary industry	Number of employees in the tertiary sector (10,000)
	Tourism adjustment ability	Self-financing level	Local revenues/local expenditures (%)
		Fiscal expenditure	Fiscal expenditure in the region (billions of dollars)
Innovation and transformation	Talent reserve	Education expenditure as a percentage of GDP	Expenditure on education/GDP (%)
		Number of college students per 10,000 people	Number of students enrolled in school/total population (units/million)
	Technical reserve	Scientific research investment level	Number of patents applied for and granted/total population (pieces/ten thousand)
		Scientific research output level	Regional research expenditure/GDP(%)

Research Methodology

Method

This are explanations of the method. In terms of Kernel Density Estimation, kernel density estimation as a common spatial disequilibrium research method can better analyze the spatial differences in tourism economic resilience(Li et al., 2024). In terms of Markov chains, the Markov chain method is one of the quantitative models used in spatial planning to analyze time series based on current values, predicting future sequence values without relying on the past or historical values of the studied sequence (Albasri et al., 2022). Markov chains represent an effective method for dynamically assessing the evolution of tourism economic development levels. The spatial Markov chain can be used to examine the influence of tourism economic resilience in the neighboring cities on the transfer of tourism economic resilience status in the city.

Regarding model assumptions and potential limitations, first, kernel density estimation assumes a spatially uniform distribution of data, while the Markov chain model assumes that future states are determined solely by the current state, neglecting the influence of historical data. As a result, these models may overlook nonlinear relationships or historical dependencies, which could impact their applicability and predictive accuracy in complex tourism economic contexts. Second, Markov chain analysis is primarily used to forecast the transition probabilities of resilience levels (high–medium, low–low) in a specific region over different time spans, and to analyze spillover effects between neighboring cities. Due to the macro–level nature of this analysis method, it cannot provide specific insights into the transformation processes of individual cities, and therefore is not suitable for detailed comparative analysis of specific cities. This limitation may further affect its applicability and predictive accuracy in the context of complex tourism economies. The study introduces an innovative methodological contribution to the research of tourism economic resilience, focusing on advanced analytical techniques. This is the integrated framework that combines Kernel Density Estimation (KDE) and Markov chains. These two methods provide a comprehensive approach to analyzing the dynamic evolution of tourism economic resilience in the Pearl River Delta. KDE is employed to visualize spatial differences in resilience, revealing regional patterns and trends. It helps identify areas with varying resilience levels and highlights how resilience is distributed across regions. On the other hand, spatial Markov chains model the transitions and dynamics of resilience over time, capturing how neighboring cities influence each other. This dynamic approach enhances understanding of how resilience shifts across regions, offering valuable insights into the temporal evolution of resilience. In short, these tools offer a

robust, multi-dimensional framework for studying both the spatial distribution and temporal evolution of tourism economic resilience. The combination of KDE and spatial Markov chain analysis provides new ways to understand the complex relationships within tourism systems and their development over time.

2. Data Collection

This study primarily utilizes data from the Guangdong Yearbook, Guangdong Statistical Yearbook, China City Statistical Yearbook, Guangdong Tourism Statistical Yearbook, and Guangdong's annual statistical bulletins on national economic and social development covering 2003 to 2022. Indexes such as domestic tourism revenue were directly obtained through database queries. Raw data were retrieved and subsequently processed for metrics like tourism resource density. The weighting of indicators was determined using the entropy weight method, which reduces subjectivity compared to expert judgment. Missing data for certain cities over consecutive years were addressed using linear interpolation or employing the average values of adjacent years. Linear interpolation was chosen because it ensures continuity and minimizes bias in long-term panel data, while more complex methods (e.g., multiple imputation) may introduce artificial volatility when applied to relatively small regional datasets. Nevertheless, linear interpolation may smooth out short-term fluctuations and potentially underestimate volatility in tourism economic resilience. All statistical analyses, including entropy weight calculation, kernel density estimation, and spatial Markov chain modeling, were conducted using MATLAB 2022b, while ArcGIS 10.8 was used for spatial visualization.

Research Results

1. The comprehensive temporal trend in the time series data within the study period in this section, the study analyzes the overall resilience of the tourism economy in Pearl River Delta from 2003 to 2022, using a comprehensive evaluation method.

First, Initial Slow Growth (2003–2007), pearl River Delta cities had low tourism economic resilience, with minimal regional disparities. Guangzhou led, but growth was limited, while Shenzhen and Dongguan showed some resilience without significant improvement. Other cities were average. Health crises like SARS (in 2003) and avian influenza (in 2005) caused temporary declines in resilience.

Second, Steady Improvement (2007–2012), resilience scores in Pearl River Delta cities rose, with emerging regional disparities. Guangzhou remained dominant, while Shenzhen

improved significantly. Huizhou showed growth potential, but peripheral cities like Jiangmen and Zhaoqing had slow progress. The 2008 financial crisis caused a brief decline in resilience.

Third, Divergence (2012–2017), high-resilience cities saw rapid growth, widening regional gaps. Guangzhou continued its strong lead, with Shenzhen and Dongguan approaching high-resilience levels. Huizhou grew rapidly, while cities like Zhuhai and Zhongshan lagged. Zhaoqing had the lowest resilience.

Fourth, Rapid Improvement and Differentiation (2017–2022), most cities saw significant resilience growth, but disparities increased. Guangzhou reached a historical high, with Shenzhen emerging as a core growth pole. Huizhou maintained high growth, while Zhuhai, Zhongshan, and Jiangmen had limited progress, and Zhaoqing showed some improvement, suggesting potential for catch-up.

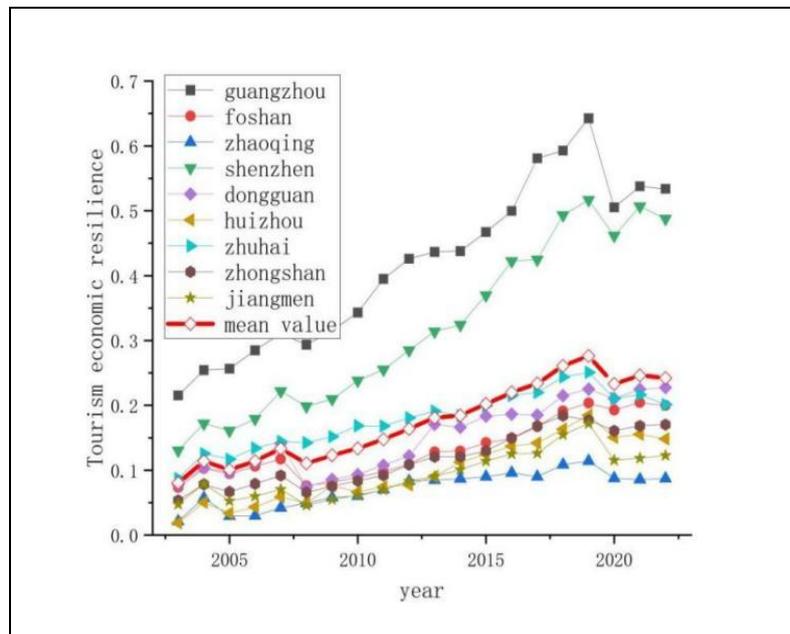


Figure 1 The result of the Resistance and recover-dimension tourism economy resilience in the Pearl River Delta from 2003 to 2022 (Source: Constructed by the researchers)

2. The temporal patterns and spatial aggregation of tourism economy resilience levels

Based on the calculated results of tourism economic resilience in the Pearl River Delta, this study utilized ArcGIS 10.7 software to map the spatial distribution (Figure. 2). The mean value of tourism economic resilience is 0.1751. Using the natural breaks classification method in GIS, the resilience levels of the cities were categorized into four types: L, ML, MH, and H. Specifically: provinces with resilience values less than 50% of the mean were classified as "Low" (L). provinces with resilience values between 50% and 100% of the mean were classified as "Middle Low" (ML).

provinces with resilience values between 100% and 150% of the mean were classified as "Middle High" (MH). provinces with resilience values exceeding 150% of the mean were classified as "High" (H). This section selected four time points—2007, 2012, 2017, and 2022, with a 5-year interval between each. It is primarily aimed at capturing the changes in tourism economic resilience at different stages and reflecting long-term trends related to economic development and external shocks.

First, from the perspective of overall spatial distribution, the tourism economic resilience of the PRD exhibits a spatial pattern characterized by "prominent in the north, outstanding in the central and southeastern regions, and weak in the periphery." High-resilience cities are limited in number, primarily concentrated in the central-northern and southeastern regions, such as Guangzhou and Shenzhen. The majority of moderately high-resilience cities are distributed in the central and southern regions, while low-resilience cities are mostly located in peripheral areas, such as Jiangmen and Zhaoqing.

Second, regarding changes in spatial distribution, the spatial configuration of high-resilience regions in the Pearl River Delta remains relatively stable, while low-resilience regions have gradually diminished. Since 2007, Guangzhou, Shenzhen, and Dongguan have consistently maintained "high" or "moderately high" resilience levels, forming the core regions. The area occupied by low-resilience regions has significantly decreased from its larger proportion in 2007 and 2012 to near disappearance by 2022, indicating a substantial overall improvement in the tourism economic resilience of the Pearl River Delta.

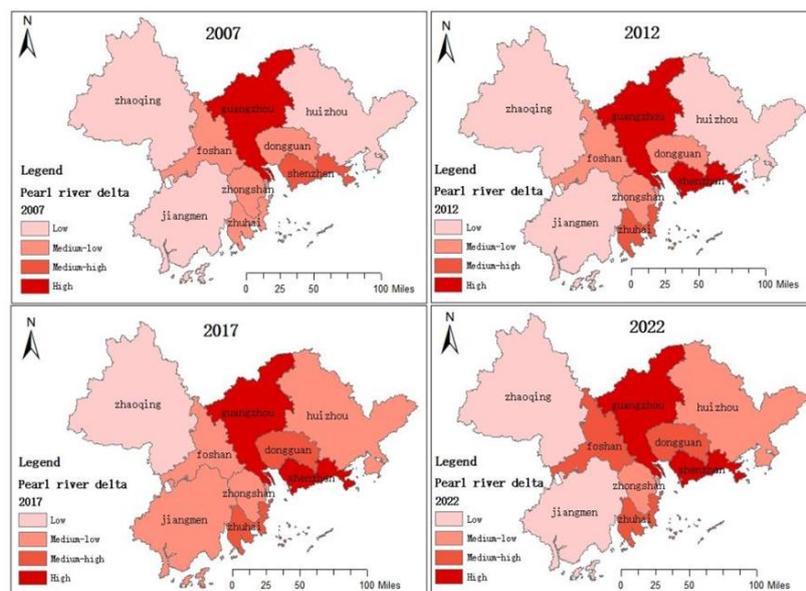


Figure 2 Spatial distribution of tourism economic resilience in the Pearl River Delta in 2007, 2012, 2017, and 2022 (Source: Constructed by the researchers)

3. The spatial dynamic evolution of tourism economic resilience in the Pearl River Delta

3.1 Traditional Kernel Density Estimation Analysis

To investigate the dynamic evolution of tourism economic resilience in Pearl River Delta, this study first employs the traditional kernel density estimation method to examine the spatial distribution evolution of tourism economic resilience in China. Using MATLAB software, kernel density estimation was applied to the Pearl River Delta's tourism economic resilience (Figure 3). To maintain consistency with the previous text, the years 2007, 2012, 2017, and 2022 were selected as study intervals to capture the dynamic changes in tourism economic resilience over time, reflecting key phases of economic development.

First, regarding overall trends, Tourism economic resilience in the Pearl River Delta is mainly low to moderately low, with slow overall improvements. The distribution is right-skewed, with the majority of cities in the low-resilience range (0–0.2), and a secondary peak in the moderately low range (0.4–0.6). While there has been some shift toward higher resilience over time, the improvement remains limited.

Second, in terms of temporal evolution, from 2007 to 2012, resilience gradually improved, with the peak shifting from the low to moderately low-resilience range, showing no significant polarization. From 2012 to 2017, disparities increased, and a twin-peak pattern emerged in the low-resilience range, signaling early polarization. From 2017 to 2022, resilience improved further, with a shift to the moderate-resilience range (0.3–0.4) and some cities showing significant improvements. However, polarization deepened, with some regions advancing while others remained low-resilience.

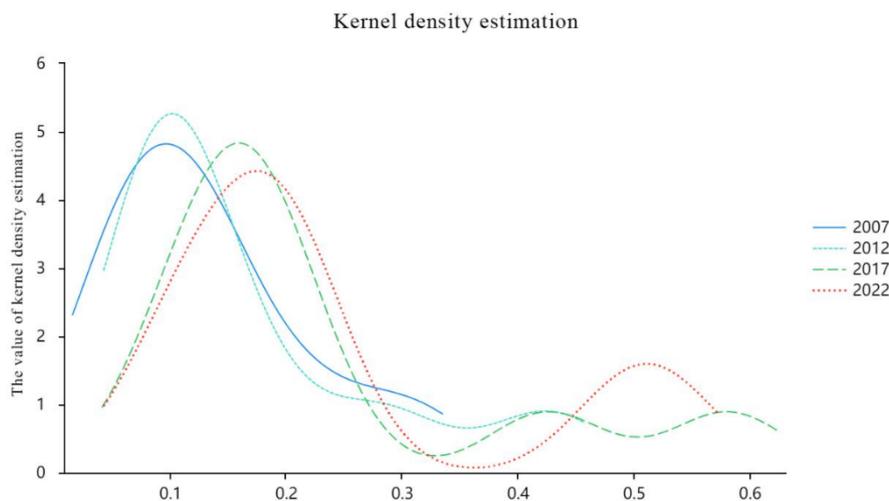


Figure 3 Traditional kernel density map of tourism economy resilience in the Pearl River Delta

(Source: Constructed by the researchers)

3.2 Markov chain analysis

To compare the transition probabilities of tourism economic resilience levels under different spatial contexts and periods, this study examines spatial Markov chains for Pearl River Delta cities with time spans of 1 year, 3 years, and 5 years. Table 2 presents the transition probabilities and directions of tourism economic resilience levels among cities based on spatial Markov chains. The results are as follows:

First, the transition probabilities of tourism economic resilience levels in the Pearl River Delta vary under different spatial contexts. As shown in Table 2, for a time span of 1 year, when spatial conditions are considered, and the neighboring city is at ML, the diagonal probabilities for ML and MH are lower than the off-diagonal probabilities. When the neighboring city is at H, the diagonal probability for ML is also lower than the off-diagonal probability. This indicates that the likelihood of transitions for ML and MH increases under these conditions while the probability of maintaining the same level decreases. The inclusion of spatial conditions alters the transition types of tourism economic resilience in some Pearl River Delta cities.

Second, regardless of the neighboring city's level, cities' tourism economic resilience tends to shift from lower to higher levels over time, though the transition probabilities vary, primarily affecting the L-to-ML transitions. From Table 2, for a time span of 1 year, with spatial conditions included, the upper triangle probabilities are generally higher than the lower triangle probabilities, particularly for the L-to-ML transitions. This suggests that cities are more likely to transition upward and less likely to transition downward after one year, with the most significant effect on the L-to-ML transitions.

Third, the improvement of neighboring cities' tourism economic resilience levels promotes the resilience enhancement of the focal city. The promotion effect is evident when neighboring cities are at ML, MH, or H levels, particularly when they transition from ML to H levels. This effect is most pronounced in the L-to-ML transition type. As shown in Table 2, when neighboring cities are at ML, for A=1, 3, and 5, the probability of L-level cities transitioning to MH levels is 100%, 0%, and 100%, respectively. When neighboring cities are at H, for A=1, 3, 5, the probability of L-level cities transitioning to MH levels is 67%, 67%, and 100%, respectively. The transition speed significantly increases. Conversely, for MH-level cities transitioning to H levels, when neighboring cities are at ML, the probabilities are 67%, 100%, and 100% for A=1, 3, 5. When neighboring cities are at H, the probabilities are 18%, 50%, and 64%. In this case, the transition speed decreases considerably.

Fourth, high-level cities exhibit exceptional stability, unaffected by spatial conditions. As shown in Table 2, regardless of the neighboring city's level for the first year, the probability of H-level cities maintaining their original state on the diagonal is almost 100%, demonstrating extremely high stability.

Table 2 Spatial Markov chain transfer probability matrix.

Local city	adjacent cities	A=1				A=3				A=5			
		L	ML	MH	H	L	ML	MH	H	L	ML	MH	H
L	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ML	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ML	L	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
	ML	0.00	0.60	0.40	0.00	0.00	0.60	0.20	0.20	0.00	0.80	0.00	0.20
	MH	0.00	0.00	0.33	0.67	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00
	H	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00
MH	L	0.67	0.33	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
	ML	0.05	0.79	0.16	0.00	0.05	0.53	0.42	0.00	0.00	0.42	0.58	0.00
	MH	0.00	0.25	0.75	0.00	0.00	0.50	0.50	0.00	0.00	0.25	0.75	0.00
	H	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00
H	L	0.33	0.67	0.00	0.00	0.33	0.67	0.00	0.00	0.00	1.00	0.00	0.00
	ML	0.06	0.63	0.31	0.00	0.00	0.33	0.67	0.00	0.00	0.20	0.53	0.27
	MH	0.00	0.06	0.76	0.18	0.00	0.17	0.33	0.50	0.00	0.11	0.25	0.64
	H	0.00	0.02	0.02	0.96	0.00	0.00	0.08	0.92	0.00	0.00	0.04	0.96

Note: Some transfer probabilities in Table 2 are shown as 0.00 due to rounding to two decimal places rather than an absolute absence of transitions.

Discussions

Firstly, the spatio-temporal analysis of tourism economic resilience in the Pearl River Delta reveals complex evolutionary patterns characterized by distinct developmental phases and spatial configurations. To interpret these patterns more comprehensively, this study employs kernel density estimation as a supplementary analytical tool. The results show that tourism economic resilience in the region exhibits a dynamic development trend, progressively shifting from low to higher levels. However, a noticeable polarization persists in low-resilience areas, where the proportion of cities with medium to low resilience remains relatively high. This suggests that, despite overall improvements, significant regional disparities continue to exist. Uneven

development remains a prominent issue, underscoring the need for differentiated strategies and policy interventions tailored to the specific conditions of each city to foster more balanced regional tourism growth. This finding is consistent with prior research highlighting spatial disparities in economic resilience between core and peripheral cities (Du et al., 2019), but the application of KDE in this study provides further evidence of the long-term, cumulative nature of such disparities, which was insufficiently addressed in earlier work.

Secondly, the spatial distribution of tourism economic resilience in the Pearl River Delta followed a distinct "strong north, prominent central-southeast, weak periphery" pattern, reflecting deeply embedded structural disparities across the region. Northern cities—particularly Guangzhou and Shenzhen—demonstrated consistently high resilience levels, likely benefiting from advanced infrastructure, strong innovation capacity, and robust policy support (Zhang et al., 2022). Meanwhile, central and southeastern areas maintained moderate to high resilience levels, potentially leveraging their advantageous locations and solid industrial foundations.

In contrast, peripheral cities such as Zhaoqing and Jiangmen consistently exhibited lower levels of resilience, hindered by limited resources and weaker integration with the regional economic core. These findings suggest the presence of complex core-periphery dynamics and limited diffusion effects, which challenge conventional assumptions regarding development spillovers (Koo, 2005; Qian, 2018). Although core cities have shown strong performance, their resilience benefits have not effectively transferred to surrounding areas. Findings suggest that geographic proximity may be insufficient without complementary conditions. These results echo the literature review's discussion of core-periphery imbalances (Cai & Xu, 2023), while also extending it by showing that spatial resilience theory alone cannot fully explain the persistence of weak spillovers in the PRD.

Thirdly, the Markov chain results reveal that high-resilience cities in the Pearl River Delta exhibit remarkable stability, maintaining their advantageous positions over time regardless of spatial conditions. In contrast, resilience transitions are primarily concentrated within the low to moderately low range, indicating that the radiative or spillover effects from core cities have not been fully realized. These findings challenge traditional regional development assumptions, which suggest that economic and developmental benefits should naturally diffuse from core cities to peripheral areas (Qian, 2018). In other words, despite the strong performance of cities like Guangzhou and Shenzhen, their resilience gains have not effectively translated into improvements in cities such as Zhaoqing and Jiangmen. Thus, mere geographic proximity to core cities does not

guarantee resilience enhancement. These insights underscore the need for more tailored, context-sensitive strategies to strengthen resilience in less-developed areas.

New Knowledge from Research

This study advances the understanding of tourism economic resilience by interpreting the Pearl River Delta's spatial polarization through kernel density estimation and spatial Markov chain results. Kernel density analysis shows a general improvement in resilience, while the spatial Markov chain indicates stable high-resilience cores and limited upward movement among low-resilience cities. These model-based findings challenge spillover and diffusion assumptions and reveal the inertia of resilience transitions, providing a clearer basis for context-sensitive strategies to promote balanced regional development.

Conclusion

Firstly, this study identifies four distinct phases in the temporal evolution of tourism economic resilience in the Pearl River Delta: initial slow growth (2003–2008), steady improvement (2009–2014), widening disparities (2015–2019), and rapid improvement and differentiation (2020–2022). These phases reflect the non-linear and regionally differentiated nature of tourism resilience development.

Overall, the findings highlight the dynamic yet uneven progression of tourism economic resilience in the region, providing a foundation for future research and policy design aimed at enhancing resilience in the face of shocks and long-term development pressures.

Secondly, this study demonstrates that the Pearl River Delta's tourism economic resilience is not only temporally dynamic but also spatially uneven. The persistent "strong core, weak periphery" pattern indicates that regional resilience is closely tied to broader structural and institutional factors, such as infrastructure, innovation, and governance capacity.

While core cities continue to lead in resilience performance, peripheral regions remain constrained by developmental limitations. These insights emphasize the need for policymakers to move beyond one-size-fits-all approaches and consider tailored strategies that address local conditions, with the aim of narrowing resilience gaps and achieving more balanced regional development.

Thirdly, this study provides strong empirical evidence that tourism economic resilience in the Pearl River Delta is characterized by long-term stability in high-resilience cities and persistent stagnation in lower-resilience areas. The limited upward transition observed among peripheral cities suggests that resilience development does not automatically follow from proximity to successful core cities.

Consequently, the traditional model of regional spillover is insufficient in explaining the current patterns of resilience diffusion. The results call for a reevaluation of regional policy frameworks and reinforce the importance of implementing differentiated, development-stage-specific strategies to promote equitable and sustainable resilience improvements throughout the region.

In summary, this spatial-temporal analysis carries significant implications for regional development policies. It highlights the need for a more nuanced regional policy that acknowledges and addresses the structural barriers to resilience diffusion. Despite overall regional growth, the persistent nature of spatial disparities suggests that current policy approaches may need recalibration to promote balanced development more effectively. These insights provide valuable guidance for policymakers seeking to enhance regional resilience while reducing spatial inequalities in the Pearl River Delta region.

Suggestions

Firstly, the study highlights significant disparities in resilience between core and peripheral cities in the Pearl River Delta. To address these inequalities, targeted policy interventions are needed in peripheral cities to improve connectivity to core areas. These efforts should aim to overcome the "threshold effect," enabling peripheral cities to reach the necessary development levels to absorb the positive spillover effects from stronger cities. Therefore, policymakers should implement phased strategies tailored to different stages of development, ensuring the sustainability of regional growth. Additionally, special support is required for low-resilience cities to prevent development polarization. Targeted interventions is crucial to avoid long-term disparities and ensure equitable development across the region.

Secondly, policies should be tailored to the specific needs of different regions, with core cities serving as catalysts for regional transformation by sharing knowledge and resources to enhance peripheral cities' resilience and long-term development (Adams et al., 2021). Current regional policies have not sufficiently facilitated resilience diffusion between core and peripheral

cities. Therefore, establishing cross-regional tourism economic cooperation zones, promoting joint marketing platforms, and integrating peripheral cities into the industrial chains are recommended to strengthen their resource absorption capacity.

Thirdly, a dynamic monitoring system should be established to track changes in tourism economic resilience across cities, with regular evaluations to assess the effectiveness of policies and ensure the scientific adjustment of development strategies. Additionally, continuous monitoring of development gaps between cities is essential to maintain balanced development. While high-resilience cities should retain their competitive advantages, long-term planning and differentiated policies must be implemented to prevent these gaps from widening, fostering the entire region's sustainable development.

References

- Adams, K. M., Choe, J., Mostafanezhad, M., & Phi, G. T. (2021). (Post-) pandemic tourism resiliency: Southeast Asian lives and livelihoods in limbo. *Tourism Geographies*, 23(4), 915–936. <https://doi.org/10.1080/14616688.2021.1916584>
- Adger, W. N., & Vincent, K. (2005). Uncertainty in adaptive capacity. *Comptes Rendus Geoscience*, 337(4), 399–410. <https://doi.org/10.1016/j.crte.2004.11.004>
- Albasri, N. A. H., Al-Jawari, S. M., & Al-Mosherefawi, O. J. (2022). Prediction of urban spatial changes pattern using Markov chain. *Civil Engineering Journal*, 8(4), 710–722. <https://doi.org/10.28991/CEJ-2022-08-04-07>
- Amul, G. G., Ang, M., Kraybill, D., Ong, S. E., & Yoong, J. (2022). Responses to COVID-19 in Southeast Asia: Diverse Paths and Ongoing Challenges. *Asian Economic Policy Review*, 17(1), 90–110. <https://doi.org/10.1111/aepr.12362>
- Brown, L., & Greenbaum, R. T. (2017). The role of industrial diversity in economic resilience: An empirical examination across 35 years. *Urban Studies*, 54(6), 1347–1366. <https://doi.org/10.1177/0042098015624870>
- Cai, X., & Xu, Y. (2023). Spatiotemporal Evolution and Influencing Factors of Tourism Economic Resilience under the Impact of COVID-19—A Case Study of Coastal Cities in China. *Sustainability*, 15(24), Article 24. <https://doi.org/10.3390/su152416668>
- Cheng, L., & Zhang, J. (2020). Is tourism development a catalyst of economic recovery following natural disaster? An analysis of economic resilience and spatial variability. *Current Issues in Tourism*, 23(20), 2602–2623. <https://doi.org/10.1080/13683500.2019.1711029>

- Cheng, T., Zhao, Y., & Zhao, C. (2022). Exploring the spatio-temporal evolution of economic resilience in Chinese cities during the COVID-19 crisis. *Sustainable Cities and Society*, 84, 103997. <https://doi.org/10.1016/j.scs.2022.103997>
- Ding, S., & Fan, Z. (2024). Spatiotemporal Evolution and Obstacle Factor Analysis of Coupling Coordination Between Economic Resilience and Green, Low-Carbon Development in China. *Sustainability*, 16(24), Article 24. <https://doi.org/10.3390/su162411006>
- Du, Y., Wang, Q., Hu, A., & Xin, Y. (2022). Influence evaluation of producer services agglomeration on economic resilience: Evidence from China's cities. *Economic Research-Ekonomska Istraživanja*, 36(3). <https://doi.org/10.1080/1331677X.2022.2151491>
- Du, Z., Zhang, H., Ye, Y., Jin, L., & Xu, Q. (2019). Urban shrinkage and growth: Measurement and determinants of economic resilience in the Pearl River Delta. *Journal of Geographical Sciences*, 29(8), 1331–1345. <https://doi.org/10.1007/s11442-019-1662-6>
- Hassink, R. (2010). Regional resilience: A promising concept to explain differences in regional economic adaptability? *Cambridge Journal of Regions, Economy and Society*, 3(1), 45–58. <https://doi.org/10.1093/cjres/rsp033>
- Hill, E., St. Clair, T., Wial, H., Wolman, H., Atkins, P., Blumenthal, P., Ficenec, S., & Friedhoff, A. (2012). Economic shocks and regional economic resilience. In *Urban and Regional Policy and Its Effects* (Vol. 9780815722854, pp. 193–274). Brookings Institution Press. <http://www.scopus.com/inward/record.url?scp=84896386778&partnerID=8YFLogxK>
- Holling, C. S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecology, Evolution, and Systematics*, 4, 1–23. <https://doi.org/10.1146/ANNUREV.ES.04.110173.000245>
- Hu, X., Li, L., & Dong, K. (2022). What matters for regional economic resilience amid COVID-19? Evidence from cities in Northeast China. *Cities*, 120, 103440. <https://doi.org/10.1016/j.cities.2021.103440>
- Huang, X., Guo, R., Li, X., Li, M., Fan, Y., & Li, Y. (2023). Research on the evolution and driving factors of the economic spatial pattern of the Guangdong-Hong Kong-Macao greater bay area in the context of the COVID-19 epidemic. *ISPRS International Journal of Geo-Information*, 13(1), 9. <https://doi.org/10.3390/ijgi13010009>
- Hu, Y., Zhou, H. Q., Jin, X. M., Shen, Y. F., & Yan, Y. Z. (2022). Assessing the resilience of the marine economy: A case study of southern China's marine economy circle. *Frontiers in Marine Science*, 9, 912462. <https://doi.org/10.3389/fmars.2022.912462>

- Hudson, R. (2010). Resilient regions in an uncertain world: Wishful thinking or a practical reality?. *Cambridge Journal of Regions, Economy and Society*, 3(1), 11–25. <https://doi.org/10.1093/cjres/rsp026>
- Jiao, M., Hu, M., & Xia, B. (2019). Spatiotemporal dynamic simulation of land–use and landscape–pattern in the Pearl River Delta, China. *Sustainable Cities and Society*, 49, 101581. <https://doi.org/10.1016/j.scs.2019.101581>
- Li, C., Yu, G., Deng, H., Liu, J., & Li, D. (2024). Spatio–temporal pattern and the evolution of the distributional dynamics of county–level agricultural economic resilience in China. *PLoS ONE*, 19(5), e0300601. <https://doi.org/10.1371/journal.pone.0300601>
- Martin, R. (2012). Regional economic resilience, hysteresis and recessionary shocks. *Journal of Economic Geography*, 12(1), 1–32. <https://doi.org/10.1093/jeg/lbr019>
- Martin, R., & Gardiner, B. (2019). The resilience of cities to economic shocks: A tale of four recessions (and the challenge of Brexit). *Papers in Regional Science*, 98(4), 1801–1833. <https://doi.org/10.1111/pirs.12430>
- Qian, H. (2018). Knowledge–based regional economic development: A synthetic review of knowledge spillovers, entrepreneurship, and entrepreneurial ecosystems. *Economic Development Quarterly*, 32(2), 163–176. <https://doi.org/10.1177/0891242418760981>
- Reggiani, A., Graaff, T. de, & Nijkamp, P. (2001). Resilience: An Evolutionary Approach to Spatial Economic Systems. *Networks and Spatial Economics*, 2, 211–229. <https://doi.org/10.1023/A:1015377515690>
- Sharma, G. D., Thomas, A., & Paul, J. (2021). Reviving tourism industry post–COVID–19: A resilience–based framework. *Tourism Management Perspectives*, 37, 100786. <https://doi.org/10.1016/j.tmp.2020.100786>
- Simmie, J., & Martin, R. (2010). The economic resilience of regions: Towards an evolutionary approach. *Cambridge Journal of Regions, Economy and Society*, 3, 27–43. <https://doi.org/10.1093/CJRES/RSP029>
- Sutton, J., & Arku, G. (2022). Regional economic resilience: Towards a system approach. *Regional Studies, Regional Science*, 9(1), 497–512. <https://doi.org/10.1080/21681376.2022.2092418>
- Wang, S., Cui, Z., Lin, J., Xie, J., & Su, K. (2022). The coupling relationship between urbanization and ecological resilience in the Pearl River Delta. *Journal of Geographical Sciences*, 32(1), 44–64. <https://doi.org/10.1007/s11442-022-1935-3>

- Wang, Z., & Wei, W. (2021). Regional economic resilience in China: Measurement and determinants. *Regional Studies*, 55(7), 1228–1239. <https://doi.org/10.1080/00343404.2021.1872779>
- Zhang, P., Huang, Y., Pan, S., Chen, W., Zhong, H., Xu, N., & Zhong, M. (2022). Does resilience exist in China's tourism economy? from the perspectives of resistance and recoverability. *Sustainability*, 14(17), 10641. <https://doi.org/10.3390/su141710641>
- Zhang, S., Zhang, F., Wang, C., & Wang, Z. (2020). Assessing the resilience of the belt and road countries and its spatial heterogeneity: A comprehensive approach. *PloS ONE*, 15(9), e0238475. <https://doi.org/10.1371/journal.pone.0238475>